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Topics of the Month

Putting the sun to work

PLAGUED by the nagging thought that the present main sources of energy—coal and oil—are exhaustible, many people in many places have looked at the sun and wondered how its energy could be utilised as a vast and, for practical purposes, inexhaustible source of heat and power. In Britain the National Physical Laboratory has had a committee of eight eminent scientists considering the utilisation of solar energy and last month they issued their report. Their conclusion, even taking the most optimistic view, is that there is at present no way in which the use of solar energy can make a large contribution to our sources of power. Furthermore, they can recommend no line of research or development that is likely to lead to a way in the near future.

Before they come to this conclusion, the scientists consider in absorbing detail the various possible ways of using solar energy—for heating water and houses, for cooking and refrigeration, for power, for the production of fuel, and, finally, for the distillation of water. Solar water heaters are sold in the U.S. but they are not very popular and it is thought unlikely that they could be promoted in Britain. A solar cooker has been designed in India but the problem is to make it cheap enough for the average Indian villager. The Committee recommend the National Research and Development Corporation in England to consider sponsoring the design of a stove suitable for mass production.

Solar energy for refrigeration is not considered practicable but there seem distinct possibilities in using it for air conditioning as it is not essential that the system run continuously as must a refrigerator.

For various reasons the Committee regretfully conclude that orthodox heat engines driven directly by the sun are not an immediate practicable proposition but they recommend consideration of a flat plate collector for driving a small engine.

To the chemist the most interesting part of the report is that on the production of fuel. Here the Committee consider photosynthesis in non-living systems (the possibility of producing compounds with more energy than the raw materials needed to make them) but conclude that such fuel-producing systems are very remote possibilities. The many ways of using plants to produce fuel are considerable but it is pointed out that the cultivation of such plants can only be done on a big scale at the expense of food production. Finally, continuous biological photosynthesis is considered but for various reasons, including the problem of supplying nutrients, this idea is also considered impracticable at present.

However, the report ends on one hopeful note: the Committee think there is scope for the solar distillation of water for drinking purposes in certain tropical areas and mention that considerable improvements have been made by introducing black dyes into the solution to increase the proportion

of heat absorbed. This innovation has already been reported in this journal (March, p. 191) and an improved solar still was described in our July 1951 issue (p. 314). We hope to give further details of the National Physical Laboratory report in our next issue.

Monopoly Commissioners report on insulin

THAT the insulin monopoly in Great Britain operates in the public interest and should continue unchanged is the verdict of the Monopolies and Restrictive Practices Commission which has been investigating the manufacture and supply of this essential medicinal for the past two years. Four companies produce the entire U.K. supply of insulin. The biggest is Burroughs Wellcome and Co. which makes 45.7%, next come Allen and Hanburys Ltd., and The British Drug Houses Ltd., who jointly make 31.8%, and finally Boots Pure Drug Co. Ltd., which makes 22.5%. In 1950 total sales were valued at £1,266,722, of which 55.8% by quantity and 60.7% by value went to the home market for the 60-70% of the estimated 200,000 diabetics who receive insulin, mostly through the National Health Service.

The four firms, who employ about 250 people on making insulin, excluding the labour for sterility and biological tests, collaborate as the British Insulin Manufacturers. One firm buys the raw material, pancreas, on behalf of all, and all exchange technical information. This technical collaboration greatly impressed the Commissioners, who state that it is through this that the manufacturers have been able to obtain higher yields of insulin and thus keep down prices in spite of rising costs of raw materials. Prices, indeed, are lower in Britain than anywhere else except perhaps Scandinavia; the standard pack of 100 units which cost 25s. in 1923 cost only 1s. 5½d. in 1950.

Pattern of expansion

WE have obtained from the Association of British Chemical Manufacturers a more detailed picture of the progress of the industry's expansion and rehabilitation schemes than that given by the chairman in his speech at the annual meeting. It will be recalled (see our November issue, p. 618) that he stated that of the £191 million-worth of schemes proposed in 1949, 41% by value had been completed, 34% were in progress, 16% postponed and 9% abandoned. The progress made by each group of projects as at July last can now be seen in the accompanying table. The figures in each column represent percentages by value based on the total value of the schemes in each group, as estimated in 1949. The first column gives the estimated cost of each scheme in 1949 but it must be remembered that in most cases the actual cost of the completed schemes is substantially greater than this estimate. In order to prevent misunderstanding, particularly about schemes which have been postponed or abandoned, the final column gives, as percentages of the total values of each group, the schemes which were only tentative in 1949.

Most of the schemes have been delayed by the steel shortage which has affected both the building itself and the equipment. The majority of those in progress, however, should be completed very soon.

Some of the postponed schemes are awaiting licences, others have been delayed for other reasons, some of them connected with the sulphur shortage and the trade trends of the past year. The abandonment of 41% of the sulphuric acid schemes is a direct consequence of the shortage of American sulphur. Some of these have been replaced by other schemes not involving the use of sulphur as such, but this has been disregarded in preparing the table which is based on schemes put forward in 1949.

The report on the industry in which the expansion schemes were described in detail, was summarised in our March 1950 issue, pp. 114-119.

Progress of the Chemical Industry's Expansion Schemes

(Calculated as a percentage of the total value of all the schemes in the group)

	Group	Estimated Cost of all Schemes 1949 £000's	Completed	In Progress	Postponed	Abandoned	Tentative in 1949
1	Sulphuric acid..	11,119	30	23	6	41	62
2	Alkalies (including chlorine)..	39,100	34	64.5	1.5	—	1
3	Other inorganic acids and salts (including carbide)	13,736	42.5	26	16.5	15	42
4	Industrial gases	4,286	14	50	25	11	47
5	Nitrogen fertilisers	3,590	19	8.5	—	72.5	100
6	Soluble phosphate fertilisers	2,468	57	21	22	—	5.5
7	Other chemical fertilisers ..	11,600	—	0.5	99	0.5	100
8	Heavy organic chemicals ..	42,794	60.5	21	13.5	5	22
9	Chemicals for pharmaceutical and veterinary products ..	7,131	35	33	19	13	44
10	Miscellaneous fine chemicals	1,862	57.5	22.5	17	3	22.5
11	Dyestuffs and intermediates	16,381	13	72.5	13.5	1	11
12A	Coloured pigments.. ..	1,928	68	3	22	7	15
12B	Other pigments (including whites and red and orange lead)	3,215	23	68	3	6	44
13	Explosives ..	2,031	7	21	71	1	100
14	Chemicals for pest control and for agricultural and horticultural purposes, not elsewhere included ..	686	38	35	7	20	33
15	Plastic materials and synthetic resins ..	21,974	67	26	2.5	4.5	18
16	Miscellaneous chemicals ..	1,947	36.5	7.5	1	55	66
17	Coal tar distillation products..	(Ex	cluded	from	report)		
18	General Services and Amenities	5,458	65	5	25.5	4.5	43
	Overall figures:	191,306	41	34	16	9	32

Radioactive study of catalyst flow

UNIFORM flow of the catalyst is essential for maximum operating efficiency in the Houdriflow catalytic cracking process for petroleum refining, in which cracking is accomplished by bringing oil vapours into contact with a solid moving bed of bead catalyst passing downward through the reactor and regenerator. The determination of flow rates of solid particles inside cracking vessels presents some difficulty, however, but the use of radioactive tracer techniques has enabled this to be done satisfactorily.

Some studies of catalyst flow, which were carried out at

the Salt Lake Refining Co.'s plant in Utah, entailed the introduction of a few pellets of radioactive catalyst into the cracking unit. The travel of the individual radioactive pellets was traced by detecting instruments placed outside the catalytic equipment, and their path and average velocity were plotted. The survey showed that catalyst circulated through all parts of the Houdriflow unit with excellent uniformity; for example, the average velocity of catalyst particles flowing down the main seal leg from the lift disengager into the reactor was measured repeatedly over a period of several weeks with a maximum deviation from the mean result of less than 5%. A statistical analysis of other data collected in this manner demonstrated conclusively that the character of catalyst flow through the various elements of the Houdriflow system is decidedly streamlined, and ensures uniform residence time of all catalyst particles in the unit. It is clear that information of this nature would be difficult, if not impossible, to obtain in any other way.

Explosives industry census

A THREEFOLD increase in the value of net output between 1935 and 1948 was achieved by the explosives and fireworks industry, according to a 1948 Production Census report issued recently. The figures were £3,700,000 in 1935 and £11,071,000 in 1948. The number of firms in the industry, defined as manufacturers of explosives, fireworks, detonators, fuses, percussion caps, flares, signal rockets, and ammunition, declined slightly during this period, from 53 to 49. However, the number of workers nearly doubled, reaching close on 25,000 in 1948. Compared with other chemical industries, the net output per employee was low, only £444 as against £755 in the pharmaceutical industry and £1,027 in the dyestuffs industry, to quote only two examples. The best *per capita* output figure was achieved by the 13 firms employing between 100 and 200; it was £507. The industry is dominated by 15 firms which employ 15,576 people and account for no less than £9,310,000 of the entire net output, that is, more than 80%.

There was an increase in the manufacture of high explosives during the period reviewed. Total propellent powders and high explosives made in 1948 amounted to 776,200 cwt., against 580,500 cwt. in 1937. On the other hand, there was a decline in the output of blasting powder, from 142,000 cwt. in 1937 to 106,400 cwt. in 1948. Output of fuses and blasting accessories rose from 139,000 cwt. to 201,000 cwt.

Among the most important raw materials of the industry are ammonium nitrate (144,300 cwt. used in 1948), sodium nitrate (101,800 cwt.), ammonia liquor 880 (9,000 tons), cotton linters (3,915,000 lb.), jute yarn (48,400 cwt.), sulphuric acid (3,000 tons), pyrites (247,300 cwt.), and alcohol (386,000 bulk gal. I.M.S. and 332,400 proof gal. other). Total cost of materials and fuel in 1948 was £7,816,000.

Of the industry's total sales in 1948, 27.9% went to other organisations under the control of the manufacturers, and 72.1% to independent buyers. Nearly 30% of sales consisted of exports; the value was £4.3 million out of a total of £14.6 million. Industrial users such as manufacturers, repairers, builders, mines, public utilities and transport undertakings, formed the biggest single category of buyers, taking 37.6% or £5.5 million of all sales.

In 1948 the industry spent £354,000 on new and £18,000 on second-hand plant and machinery and £66,000 on vehicles of all kinds.

A year of fuel research

BY the publication of the Report of the Fuel Research Board and of the Director of Fuel Research for the year 1951, the pre-war practice of presenting reports annually is resumed. The report shows that all the research programmes started or resumed after the war have begun to yield results of value in steadily increasing amount.

It is well known that there is a growing shortage of supplies and reserves of the best coking coals and that other more plentiful coals will in the not far distant future have to be used to provide coke for the metallurgical industry. The work of the Fuel Research Station on the blending of coals for carbonisation to produce metallurgical cokes of acceptable quality is thus of great importance. This work has now shown that as much as 30 or 40% of weakly-caking coal may be incorporated in the blends without seriously affecting the quality of the coke. The carbonising conditions which give the best coke from certain of the blends have been determined.

To increase the use of finely-divided low-grade fuels and thus release higher-grade fuels for other purposes, experiments on the gasification of small-sized non-caking coal by the fluidised-solids technique have been continued in a small pilot plant producing about 350 cu. ft./hr. of water-gas. The heat required for the process is supplied to the generator from a surrounding fluidised bed of burning fuel. Successful experiments lasting up to ten days have been carried out with this unit and satisfactory water-gas has been produced. It was found, however, that this method cannot easily be applied to the production of producer gas from coke breeze, and a slagging cyclone generator has now been constructed for this purpose, the small coal or coke breeze being maintained in suspension at high temperatures.

The use of pulverised coal as a home-produced fuel for gas turbines is an attractive possibility and is being investigated actively. Experimental work has been concentrated on the design of a vortex combustion chamber, and on a straight-through combustion chamber working with a fuel research station grid or multijet pulverised fuel burner. Both of these combustion chambers operate without slagging and burn about 500 lb./hr. of pulverised fuel at atmospheric pressure. This would correspond, when operating under pressure to fire a gas turbine, to a fuel consumption of about 2,000 lb./hr. and a power output of 2,000 h.p.

Work on boiler efficiency has been continued and efforts have been made to apply the principles of smoke elimination, developed for the Lancashire boiler, to the vertical type of boiler, which is much used in industry. Some improvement in efficiency has so far been achieved and the work is being continued with the object of effecting an improvement as great as that previously achieved with shell boilers of the Lancashire type.

Investigations aimed at increasing the availability of water-tube boilers by reducing the formation of deposits on the outsides of the tubes have been continued throughout the year for the Boiler Availability Committee, and much progress has been made in dealing with this difficult problem.

The work on the Fulham-Simon-Carves ammonia process for the removal of sulphur compounds from boiler flue gas and the recovery of the sulphur as ammonium sulphate and elemental sulphur has received an added incentive, not only from the continued shortage of sulphur, but also from the rise in price of sulphur and its compounds which has made the process less costly than was at one time thought.

Experiments in the small pilot plant which treated 1,000 cu. ft./hr. of flue gas have been completed satisfactorily. A larger unit to treat 25,000 cu. ft./hr. has been built and work with it has been started.

In addition, considerable progress has also been made in the other programmes of the Fuel Research Station on the Fischer-Tropsch process for the synthesis of oil, the testing of domestic grates and stoves and more fundamental researches in the field of domestic heating, on coal chemistry, the physics and chemistry of catalysts, and on the structure of fuel oils. The Fuel Research Station has continued to organise the nation-wide survey of atmospheric pollution, with the collection and correlation of the observations, and the work is being extended by specific researches in the meteorological and other factors affecting the dispersion and incidence of pollution.

Purification of zirconium

A RAPID, convenient method for freeing zirconium of common impurities has recently been developed by W. S. Clabaugh and R. Gilchrist of the U.S. National Bureau of Standards. The zirconium is obtained as the sulphate in good yield and very high purity. The method also provides a new technique for preparing zirconium oxide which may find application in commercial preparation of the metal.

Because of the complex nature of zirconium salts and the incomplete knowledge of their chemistry, the purification of zirconium has until now been a difficult matter. As a result, most laboratories have had to use zirconium in whatever purity they were able to purchase it. The N.B.S. method, however, makes it possible for each laboratory to obtain zirconium free of all common impurities except hafnium.

It was found that, when concentrated sulphuric acid is poured into a fairly concentrated aqueous solution of zirconium sulphate or chloride, a dense white crystalline precipitate of $Zr(SO_4)_2.4H_2O$ is formed. This compound is soluble in an equal weight of water. By dissolving the precipitate in water and reprecipitating the hydrated sulphate several times, zirconium sulphate of high purity is obtained.

For best results, one volume of concentrated sulphuric acid is added to two volumes of concentrated zirconium solution. The zirconium sulphate precipitate is caught on a sintered glass filter of medium or coarse porosity and washed with acid and acetone solutions. A small amount of hydrochloric acid is added during recrystallisation to prevent the precipitation of any iron that may be present as an impurity.

The solution used to wash the precipitate consists of 75 vol. of water, 40 vol. of concentrated sulphuric acid and 5 vol. of concentrated hydrochloric acid. After several washings with this mixed acid, three washings with acetone are recommended. Alcohol, however, cannot be used for this final washing because in some way it causes interference in subsequent recrystallisations, probably through complex formation.

In a recent test run at N.B.S., the method was applied to 1,135 g. of commercial zirconium chloride containing about 0.3% of iron and 2.7% of hafnium. The zirconium chloride was dissolved in water to make 2.1 l. of solution, 1 l. of sulphuric acid was added, and the resulting product was recrystallised five times. A 70% yield (1,212 g. of zirconium sulphate) of high purity was obtained. Chemical analysis of the final product showed that it contained less than 0.1 p.p.m. of iron and less than 0.1 p.p.m. of copper. Spectrochemical methods gave a silver content of less than 1 p.p.m. and less than 10 p.p.m. each of calcium, magnesium, sodium and silicon. No other elements except hafnium were detected spectrochemically. A trace (about 0.01%) of chloride ion was present, but this could be removed merely by recrystallising the zirconium sulphate from water containing no hydrochloric acid after the iron had been eliminated.

The final product formed upon ignition of the hydrated sulphate was examined by *x*-ray diffraction and found to be the monoclinic form of ZrO_2. Thus the N.B.S. procedure also provides a convenient method for obtaining the oxide.

Hungary's mineral discoveries

THE mineral wealth of Hungary, which includes coal, petroleum and what is claimed to be one-tenth of world bauxite deposits, makes her one of Russia's most valuable satellites. According to a recent statement of the Hungarian Government, this mineral wealth is being exploited more intensively than ever before, probably because of Russia's increased demands for oil and aluminium consequent upon the new Soviet Five-Year Plan. It is claimed that since 1945 experimental drillings for water, coal, ores, oil and natural gas have equalled a quarter of the drillings carried out during the previous hundred years. Before the war six oil and natural gas fields were being operated. Since 1948 a further six fields have been put into operation.

Before the war coal output hovered around 10 million tons p.a. In 1950 a five-year plan was launched with a target of 18 million tons of coal p.a. During the first year output was raised to 13 million tons. Last year it reached 15 million. Now the target has been increased to 27.5 million tons. In recent months new pits at Petöfibánya, Kányas and Pilis have been opened. A new deposit at Tatabánya, where a 2 to 5 m. thick seam has been discovered 3 to 6 m. below the surface, is being exploited at the rate of 1,000 tons/day by the opencast method.

Hungarian mining machinery production is to be doubled during 1952. The Bámért factory at Ujpest, a suburb of Budapest, has been rebuilt and enlarged and given over entirely to mining machinery manufacture. They manufacture the Hungarian-designed Ajtai-Szilárd cutter-loader. A considerable amount of Soviet machinery is also used in the Hungarian mines, and recent imports from that country include 400 electric drills and 20 loaders.

The estimated deposits of 300 million tons of bauxite in Hungary are reckoned to be one-tenth of world reserves and six-tenths of European deposits. Before the war most of the mines were German owned and in 1938 549,000 tons of bauxite were extracted, of which 94% were exported. Today bauxite output is claimed to be considerably higher and aluminium ingot production 20 times greater than in 1938. A new aluminium plant was opened at Almasfuzito early in 1951 and another plant is to be built at Inota, where a big electric power station began operation last autumn.

Lead and zinc are among the minerals revealed by the new prospecting drive and extraction is due to begin next year. Home needs are expected to be filled by the end of the following year. The mining of fluorite, gypsum and talc has also begun. Finally, it is claimed that enough of the following minerals has been discovered to meet all home needs and to provide some for export: manganese, quartz, glass sand, casting sand, cement marl, trass (volcanic ash containing about 59% silica and 18% alumina), earth colours, silica, kaolin and bentonite.

Cold Extraction of Oils and Fats

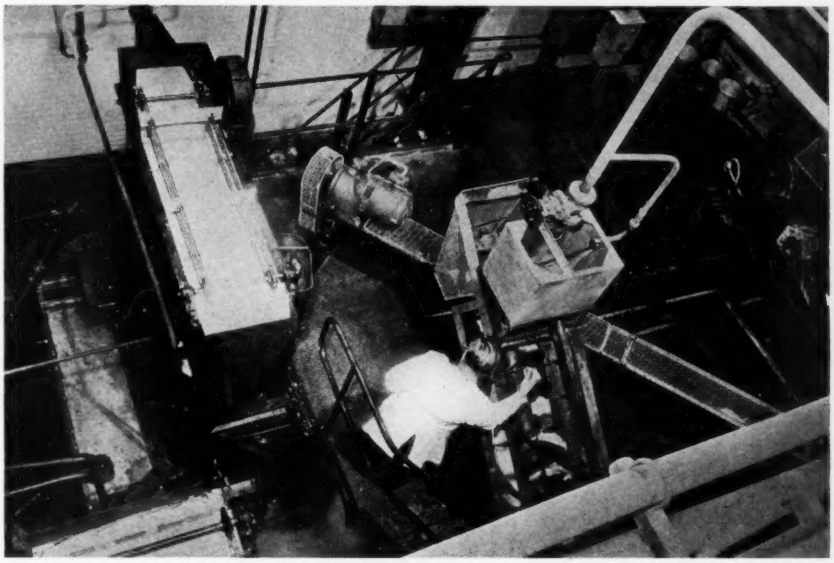
NEW BRITISH PROCESS USES COLD WATER INSTEAD OF HEAT AND SOLVENTS

Oils and fats can be extracted from natural cellular materials with ordinary cold water by a completely new process called 'impulse rendering,' developed by British Glues and Chemicals Ltd. The process is claimed to be the first technological advance in fat rendering for fifty years. It is continuous, remarkably quick, saves fuel and produces a high grade product. Already it is being used commercially in four plants to degrease bones for glue-making. Now, pilot plant experiments on fish, fish livers and coconut are under way.

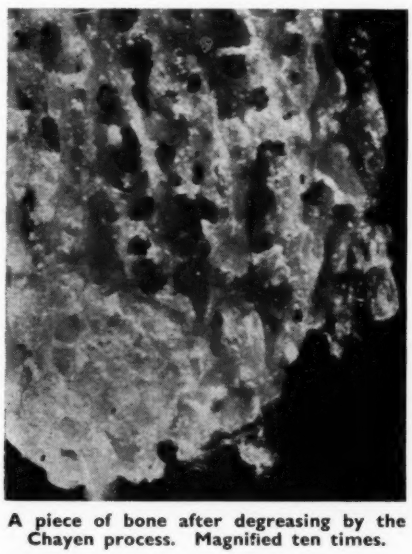
THE fundamental operation common to all producers of oils and fats is that of rendering, the rupture of the cell walls inside which the fats and oils are confined, and their removal, with the maximum recovery and the minimum degradation in quality from the parent material. Rendering has always been synonymous with heat. From the earliest days, animal fats in particular have been extracted by cooking, roasting or hot solvent, all using heat to destroy the cell tissues and free the fat. That heat is undesirable has been long understood. The darkening in colour, the progressive increase in smell and the contamination with degradation products brought about by heat on these sensitive materials have exercised the ingenuity of many generations of oil technologists and many process variations have been designed to minimise the damage done by heat in the rendering operations.

It has fallen to the research and development team of British Glues & Chemicals to develop a rendering process which is entirely independent of heat and uses only cold water and mechanical energy to open the fat cells and remove their contents. Like most discoveries, the original line of research, in this case the prosaic one of trying to find a means of rendering fats from bone without injuring their protein content, led on to further achievements.

The process, which bears the name of



General view of the British Glues bone degreasing plant at Stratford, London. (*Left*) Fat collection tank. (*Right*) Degreased bone being wormed upwards for washing and subsequent drying.



A piece of bone after degreasing by the Chayen process. Magnified ten times.

Mr. I. H. Chayen, technical director and assistant managing director of British Glues, is based on the new principle of 'impulse rendering.' This consists of passing the material to be rendered, suspended in a continuous stream of water, through a vessel in which powerful beaters subject the water to a series of high-speed and high-frequency mechanical impulses. Under these conditions, the water acts on the cell walls like a battery of pneumatic drills and they are instantaneously torn open and their contents washed away. This instant removal of the fat or oil from the zone of agitation prevents any tendency to emulsification.

In the British Glues plants, which are now working this process for the degreasing of bones and the production of high-grade tallows, the bones, suitably broken up, are fed in a continuous stream of cold water through the impulse renderer at the rate of 2 tons/hr., being subject to impulses moving at the rate of 12,000 ft./min. The rendering takes rather less than a second and the fat comes out as a bland, white solid of high purity. The fat and degreased bone are then separated by gravity and go by separate routes through a series of washing and separating processes. The fat goes into storage ready for despatch 3 min. after the bone is loaded into the plant. The degreased bone is ready for glue making or drying for dispatch within 8 min. of the start of operations. All operations are continuous and automatically controlled.

This process, which British Glues are already operating at three of their British plants and also in Toronto, produces animal fats of significantly higher quality than hitherto achieved from these materials and production from these factories is taking the place of imported high-quality fats in a number of industries. Indeed, it has been necessary to establish new and improved quality standards to classify the new quality range of fats now in production.

Advantages

Improvement in quality has been mentioned first because it represents perhaps the greatest need of the British animal fat industry, both industrial and edible. The advantages of a continuous process taking a few minutes against the batch operations taking many hours in the heat rendering processes in general use, are many and important.

Fuel usage is cut tremendously; so are plant area and capital costs. The process is completely automatic and the materials are untouched by hand. What was classi-

After bones have passed through the impulse renderer, the fat immediately comes out, floating on top of the water. Degreased bone falls to the bottom.

fied as a ' nuisance industry ' becomes one with vastly improved working conditions.

Other applications

The principle involved of impulse rendering is thought to be applicable to the whole range of fat- and oil-bearing materials all over the world, and with similar striking results.

The British Glues team, with the establishment of their latest plant in London, have merely completed the first phase. Requests have come from many sections of the oils and fats industry for information on the application of this principle to many oil-bearing materials.

The first successful application looks like being in the fish liver oil industry. Here the cold extraction of valuable high-vitamin-containing edible oils may have a far-reaching effect on future development.

Work is going on at the same time on the application of the principle to the herring industry. Here the object is to produce high-quality oil and palatable, odourless fish-meal of low oil content, which have been sought by the fishing industry for many years.

It has been established that the principle is applicable to the vegetable seed and nut industries, which are, of course, by far the largest source of oils and fats in the world. A long list of such products awaits testing, but the principle is so new, the field so vast and varied, and the number of workers trained in this technique so necessarily limited, that it is impossible to predict how quickly and in what directions the next developments will happen.

The Chayen process is entirely British in its inception and development. It might well become a dollar earner of some significance, and indeed the Sharples Corporation, one of the leaders in the engineering industry of the United States, have already been granted the agency for North America. Technical staff of the Sharples organisation have been trained in England and are now setting up demonstration plants in the U.S.

Crushed bones at the top of a conveyor belt en route to the impulse renderer.

Polythene from Natural Gas

SINCE it was accidentally discovered in 1933 by two I.C.I. chemists during studies of chemical reactions at high pressures, polythene has become one of the most versatile plastics known. It is made by the polymerisation of ethylene in a series of reactions at extremely high pressures.

Indicative of the continuing increase in the demand for polythene is the decision of Canadian Industries Ltd., an associate of Imperial Chemical Industries Ltd., to build a plant for its manufacture at Edmonton, Alberta. Edmonton is an excellent choice for a site because it is in the heart of the newly discovered oilfields from which C.I.L. will draw supplies of natural gas to provide the starting material, ethylene. The company is additionally fortunate in that Alberta natural gas is richer than any other found in North America in the component, ethane, which is a highly suitable source of ethylene.

Until recently farmland, the Edmonton site is near three petroleum refineries. The works, expected to be completed late in 1953, will comprise six main groups of buildings, the administrative offices, power house and cooling water system, ethylene plant, compressor and reactor building, warehouse, and repair shops. More than 200 persons will be employed and the initial output is planned to be more than eight times the quantity now available by importing from the U.K. and U.S.A.

Manufacture of polythene

At Edmonton, 10,000,000 cu. ft./day of natural gas will arrive through a 20-mile pipeline from the oilfield. Ethane, the special component which is to be converted into ethylene, will be extracted from this gas; part of the remainder will be used for fuel within the works and the rest will be returned into the pipelines supplying domestic gas to the city of Edmonton.

The ethane will be converted into ethylene in a cracking furnace. Essentially, this operation consists of passing the gas through an alloy steel pipe heated almost to a white heat in a gas-fired oven. The cracked gas then contains 30-40% of the desired ethylene and this is extracted and purified in a series of distillation columns. The pure ethylene goes to the polythene plant proper for compression in a series of gas compressors, some of them driven by machines of more than 600 h.p. each. The manufacture of polythene utilises pressures higher than any other process known in commercial operations anywhere in the world. Consequently, not only the compressors but also all the pipelines, valves and associated equipment have to be of extremely massive construction. Yet at the same time the highest precision is necessary to eliminate all risk of leakage and distortion. Under this extremely high pressure ethylene is fed into the reactor, in which part of it polymerises to polythene.

Operating conditions in the reactor have to be controlled to maintain a constant quality of polythene and care must be taken to avoid conditions which lead to violent explosions encountered in the early studies. The product has to be removed from the reactor as fast as it is formed in order that the process may be carried on continuously. Furthermore, all these operations must be carried on by remote control because of safety considerations.

Final product

The polythene, after separation from the unchanged ethylene, which is recompressed to be used again, will emerge at a temperature above its melting point, in a viscous white form. This is then chilled and chopped into pellets or flakes about the size of grains of wheat, ready for transfer to large storage bins in the warehouse. From there it will be packed into 50-lb. multi-wall paper sacks ready for shipping.

Polythene has found hundreds of applications including prosthetic surgery, electrical cable insulation, bottles, containers, wrapping film, etc. In the chemical laboratory, polythene bottles are used for holding hydrofluoric acid, one of the most corrosive liquids known.—*Condensed from an article by Maurice Valois in the " C.I.L. Oval."*

Industrial stoneware. ' Shaping the Needs of Industry ' is the title of a handsome booklet which describes the range of industrial ceramics, including acid tanks, storage jars, pipes, porcelain laboratory ware, electrical insulators and industrial sanitary fittings, manufactured by Doulton & Co. Ltd. The firm is probably better known as the makers of Royal Doulton china and it is the purpose of the new booklet to publicise their considerable range of industrial ceramics.

A Modern Approach to Chemical Engineering Research

By Dr. J. M. Coulson, A.M.I.Chem.E.

(Department of Chemical Engineering, Imperial College, University of London)

The empirical approach has been of great value in solving many chemical engineering problems and, indeed, there are some which might still be profitably studied on this basis. However, it now appears that certain basic operations can be improved only by going back to fundamentals. This concept is discussed in greater detail in the following article, where it is illustrated with reference to three common operations: mass transfer, drying and agitation.

'*Today our field is based largely on the application of concepts developed by the physicists and the physical chemists. If we look at any one of our major unit operations it is amazing how crude our fundamental concepts are and how little the chemical engineer has contributed to them.*'—E. R. GILLILAND

THE necessity for and extent of research in chemical engineering have both been stressed in a number of ways in recent months. Thus the Cremer report[1] brought out very clearly the inadequacy of the present facilities for this work if we are to compete successfully with America and with Continental countries. Sir Harold Hartley, in his presidential address to the Institution of Chemical Engineers, outlined the way in which chemical engineering had grown to become the fourth primary technology and emphasised the need for research to bring this country clearly ahead of others and not to have to pay heavily for 'know how.' This subject is also implicit in the recent discussion by the American Institute of Chemical Engineers on 'Whither Chemical Engineering Science.'

The nature of the work has received much less publicity and it is worth while examining just what is the nature of the work and, in particular, to note the changing theme in this field of applied science. In this respect the quotation above,[2] from an address by Prof. Gilliland, is worth considering in relation to the work done in Britain. The range of activity may be divided into three sections: fundamental, that applied to particular processes, and that dealing with the design and construction of chemical plant. Of these, the applied is largely confined to the large chemical companies and research organisations and frequently involves units that are too large for university work. Plant design and construction is again outside the province of universities, although their work should lead to a better understanding of, and hence improvement in, existing equipment. By showing the mechanisms involved, it may suggest new types of equipment. The link between those doing fundamental research and those in the engineering firms is weaker here than in America, where engineering firms sponsor considerable research on chemical plant. It is not the intention to stress research in chemical plant construction, but it does seem unfortunately true that Britain has been backward in developing process equipment. For instance, in the range of continuous centrifugal extractors and continuous filters the American and Continental firms seem more alive to new methods and we are left to make under licence or buy from abroad. One of the largest groups carrying out fundamental research is the universities and it was about their work that Gilliland was speaking and which we shall now consider in more detail.

University research

Examination of the form of chemical engineering research over the past 15 years will show a sharp change in the methods adopted and in the attitude to what is really wanted. The concept of unit operations put forward some 30 years ago divided the subject into what were too easily regarded as separate sections. These divisions spread into the research schools and the tendency was to calculate capacity coefficients for standard types of units, *i.e.* the number of theoretical plates in small rectifying columns, the capacity of filter presses, or of small evaporators. This type of work meant operating small versions of industrial equipment to find the effect of changes in operating variables, frequently pushing the variables to limits outside those possible in commercial systems. Thus flow rates in columns have been taken up to flooding rates and flow rates in heat exchangers to uneconomically high values. Again, with mixing, the power input was correlated somewhat empirically with agitator speed and a few geometrical dimensions such as propeller diameter and baffle width.

This type of research has proved very useful in the rapid development of the chemical and petroleum industries, but has contributed relatively little to the fundamental basis of the operations. The chemical engineer started with a well-filled storehouse of classical physics, which he has developed into physical technology. However, he has made relatively few additions to the basic ideas, but has tended to stretch the classical concepts into regions where they do not really fit. We can see this kind of thing by looking at the commonly used techniques for handling problems in mass transfer, drying and agitation.

Mass transfer

Mass transfer problems involve essentially diffusion rates and the ideas of equilibrium between phases. The two-film theory came into the chemical engineering literature some 30 years ago and was based on the fundamental ideas of diffusion given by Maxwell and Fick. This idea has now been applied to equipment such as packed towers where the necessary physical conditions do not exist. In such towers not only is it difficult to form a picture of the nature of the interface, but the non-uniform flow over the cross section together with the unknown residence time in the unit make it impossible to get a mathematical expression for the flow system. In fact, we are still without a generally accepted equation for the evaluation of pressure drop for flow in a two-phase system. Yet the literature, particularly that from America, is full of data on the performance of small towers of this kind in all fields of mass transfer. Gilliland doubts if this is the best use of time for university research, as it does not contribute to the fundamentals. It was, of course, excellent in the beginning as it gave some sort of guidance and yardstick to designers. To cope with these complexities we have had the idea of the Height Equivalent of a Theoretical Plate (H.E.T.P.), which has lost ground academically, as it really envisages a stepwise change in concentration, whereas in a tower the concentration is continuously changing. This has been replaced by a method using the Height of a Transfer Unit (H.T.U.), where the continuity of the process is covered by using the integrated ratio of the change in concentration to driving force. Unfortunately, this idea has lost much of its anticipated virtue, since on further examination it is found that the H.T.U. varies with flow rates and concentrations. In order to correlate the experimental results for such apparently simple systems as wetted wall columns, it has been necessary to develop complex equations which mask the physical ideas underlying the process.

In fact, with these transfer operations

we are neither sure of the mechanism nor of the driving force. Recent experiments on liquid-liquid extraction suggest that surface tension or even molecular arrangement of the molecules play a prominent part in determining the rate of transfer, yet at present there are no such terms in equations for calculating mass transfer. There are signs that this lack of basic understanding of the processes is realised and that the study of the mechanism of the unit operations is still a major field for fundamental research. At the Imperial College, London, and elsewhere concentration is now on what we believe to be the elements of the processes and which may be common to several unit operations. Thus in many diffusional operations transfer of material occurs across a surface in the form of a bubble. Such transfer occurs during the formation of the bubble, its rise through the equipment, and whenever it coalesces. Yet our existing equations all presume steady-state conditions. The newer ideas suppose formation of fresh surface as material flows through equipment, and require the measurement of the actual interfacial velocity. Such work involves a departure from measurements of performance in terms of capacity coefficients and requires apparatus designed to elucidate mechanism and not to reproduce in miniature industrial conditions. It is a reflection on our lack of basic data that this work has involved measurement of the velocity of rise of bubbles in various liquids. This form of work has been described by British workers.[3, 4, 5]

Drying

This changing approach can also be seen in the study of drying of solid particles. Thus from the general concept of constant rate and falling rate periods we are now trying to find the actual forces that promote the movement of the water in the solid during drying.[6, 7] This involves constructing artificial beds of solids such as graded glass spheres where the geometry is known and the surface forces in the pores can be calculated. It is from results of such work that one can turn slowly to the drying of specific materials of commercial interest. Looking at the work on agitation, it is no longer the capacity or power required by a given mixer that is measured, but attempts are made to study the flow pattern required to promote agitation and then to see how it can be built up. Mixing is regarded either as a branch of hydrodynamics or perhaps as another diffusion process. To say that mixing is an art and not a science is really to say that we have not yet defined the operation in an ordered manner. The modern approach aims at understanding the conditions in a mixer and not at obtaining some empirical relationship for any given mixer.[8, 9]

Whilst the general trend in the field of mass transfer and to some extent with drying and agitation represents a re-examination of the processes to understand the underlying mechanism, there are other sections where we have by no means exhausted the value of the more empirical approach. The geometric complexity of multipass heat exchangers and the difficulties in reproducing the same surface in the study of boiling, necessitate the use of somewhat empirical expressions. Again, with filtration processes the tendency is to try the material on a small unit rather than to argue from theoretical principles which are difficult to apply to actual cases.

These examples, taken mainly from the work at one of our research schools, show that in Britain we are aware of the need for a renewed examination of the principles on which the unit operations are based. In these fields, as also in that of phase equilibrium, the chemical engineer has to some extent taken over the work of the physical chemists. However, it must not be supposed that this form of work will of itself bring marked improvements in chemical plant. As stated by Sir Harold Hartley, detailed analysis of plant performance must reveal gaps in our knowledge which only large-scale investigations will solve. Examination of the literature will show that there are very few reports on what might be termed the engineering research required to construct the best chemical plant.

This is an unwelcome gap, since it is clearly desirable to assess the implication of fundamental research by examining the results of applying it to large-scale plants. Whilst the problem of scaling up is to some extent susceptible to mathematical analysis, there are many occasions in which it would help those doing fundamental research if the performance of commercial units were more freely available. Keeping to the topics discussed above, some of the weaknesses in the interpretation of laboratory data on packed columns might be clarified if data on large columns were freely available. Thus the true effect of packing size and the extent of channeling would be better indicated from commercial towers rather than by extrapolating data from small towers even when they are operated as far as possible in a similar manner. The same is true with agitators and driers; data from large units would help in assessing the shortcomings of existing theories derived from laboratory work.

Prof. Gilliland's warning and criticism of the past form a valuable reminder of the need for fundamental work, but the British tradition for scientific work has a strong influence in the chemical engineering field. There are, in fact, relatively few instances of direct applied research being done in the chemical engineering laboratories of our universities.

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Chemical-recovery coke ovens

Essentially, there have been no basic or radical changes in chemical-recovery coke oven designs and practice, but nevertheless a number of improvements and advances have been made which are significant and which have contributed valuably to the production of coke and hence to the iron and steel industry, the most substantial user of such fabricated material.

There has been no marked change or trend in the size of chemical-recovery coke ovens in recent years and the oven chambers are much the same as before, although there has been some slight increase in their horizontal taper. A notable development has been the use of a slight flare in the upper part of such chambers and the use of vertical flues is now general.

Also, important modifications have been made in heating systems, and burners are now located close to the air port level and, as well, in flue and regenerator design, including electrical precipitation to reduce or remove undesirable material from the underfiring gas.

Generally, in construction, improvements have been made in the refractory materials used. Oven tops are thicker, insulation has been added and charging holes placed to better operating advantage.

Important in chemical-recovery coke oven practice is the appurtenant machinery in which substantial improvements have been made, in charging the ovens, in facilitating door handling, and in conveying the coke to the quenching operation. Mechanical methods for charging the coal rapidly and control devices have been introduced to synchronise the operation of oven machinery, to the end of increasing safety and expediting operation.

In conclusion, mention should also be made of improvements in the distillation or chemical by-product operations in coke oven practice to the end that the equipment and its control are directed toward the recovery of maximum yields of the various chemicals in an enhanced purity of the finished products.—*From 'The Iron and Steel Industry,' Vol. 5 of 'An Engineering Interpretation of the Economic and Financial Aspects of American Industry,' Armstrong & Co., New York.*

MODERN INDUSTRIAL CENTRIFUGES

By E. Ruegg*

In this article the author discusses four types of centrifuge. Two of them, the vertical and worm or screw centrifuges, are fairly conventional. The other two, the scraper and push-type centrifuges, have been developed to their present forms rather more recently. Consequently, the author considers them in more detail. Both machines have been designed for heavy duty and high output and they are now used widely in the chemical and process industries.

IN the chemical and allied industries centrifuges are used for many processes, such as clarifying liquids, separating substances, drying salts, etc. Centrifugal force is used to effect these processes according to the properties of the materials concerned and requirements.

Vertical centrifuge

The vertical centrifuge is the conventional design. The shaft is vertical and the basket is either supported underneath or suspended from above. The machine is generally charged and discharged manually when at a standstill. According to the design, discharge takes place through the top of the basket or through holes in the floor. Even if the various operations of the vertical centrifuge are made automatic and special accelerating and braking devices incorporated, the process is essentially discontinuous requiring almost constant observation. Moreover, the short acceleration time of the basket, reduced to a minimum in the interest of increased production, causes significant power peaks and necessitates corresponding dimensioning of the electrical equipment. Power recuperation during braking is seldom worth while.

Discontinuous batch operation also necessitates auxiliary equipment of adequate capacity, such as storage tanks, pipelines, conveyor systems, etc., so that the production process itself can be carried out continuously. Further, the capacity of the vertical centrifuge is limited for the reasons mentioned. Thus, although this type is still the most suitable for many operations, it is not really suitable for modern continuous processes.

Scraper centrifuge

The scraper centrifuge is so called on account of its method of discharge, the material being scraped or scooped out of the rotating basket by suitable devices. This method is used to a certain extent also with vertical centrifuges, but it can only be carried out at very reduced speeds because of the pendulous axis of the basket and the fact that the material has to be discharged through holes in the floor.

The scraper centrifuge, however, differs from the vertical unit in that its shaft is supported rigidly and horizontally. This arrangement enables unloading to be carried out at the full peripheral speed of the basket with unhindered emptying of the separated material.

*Escher Wyss Ltd., Switzerland.

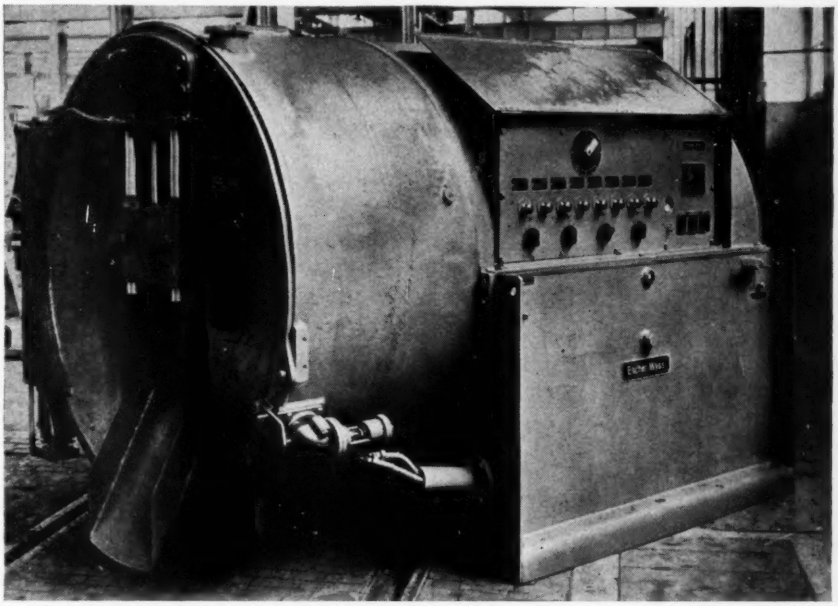


Fig. 1. Scraper centrifuge for a chemical works showing the automatic control unit and panel.

The emptying devices comprise scrapers or scoops and scrapers, according to whether the materials to be handled can be filtered, or whether separation into components depends on differences in specific gravity. The first types built were fitted with spoonlike scrapers which moved continuously backwards and forwards into the material in the basket. Only after increased operational experience and the subsequent development of the machines themselves was it possible to remove solid cakes in one action by means of a scraper covering the whole width of the basket. This unloading process lasts only a fraction of a minute with most modern machines.

The scoops are used to remove liquids separated from the solids and forming layers above the latter.

Of the wide range of operating mechanisms available for the unloading devices, only the hydraulic servo-motor has proved really suitable. It can be regulated easily and ensures flexible operation. Simultaneously, the moving parts are always well lubricated and therefore cause minimum wear. The foregoing are important factors for machines of this type.

The material is removed from the machine by means of a chute, when solid, and through telescoped pipes when liquid, and in the latter case sight glasses are often fitted.

An important part of the scraper centrifuge is the filling device. It must feed the material to be centrifuged into the basket, which is running at full speed, in such a manner that uniform distribution and hence balanced running of the basket is ensured. At the same time, the gravitational or falling energy of this material should also be utilised as far as possible, in order to keep down the power peaks of the machine during filling. The designing of these feed pipes requires numerous investigations, particularly since the materials to be processed vary greatly, *e.g.* the state of the solids, viscosity of liquids, concentration, etc., and they require reliable but simple adjustment of the filling devices for each case. A correctly loaded scraper centrifuge is exactly balanced when full and runs without vibration.

The fact that, as the basket is rotating at full speed the greater part of the liquid is removed during charging, as well as the need for uniform filling, demand quick feeding of the centrifuge. In this way more liquid is fed into the basket per unit

of time than is separated out which facilitates, in turn, uniform distribution of the solids in the basket.

Another essential for correct operation of the centrifuge is the provision of suitable storage vessels and feed valves as well as the correct layout of the plant.

A further important component, as in all centrifuges, is the filter. There is one essential difference between the vertical centrifuge and the scraper type. With the latter, a layer, several millimetres thick, of the material being handled is always left on the filter, whereas the vertical centrifuge is generally discharged right down to the filter surface. Although this layer cannot be avoided because the scraper must not pass too near the filter, it has the advantage of acting as the filter and thus automatically adjusting itself to the material. This also ensures the production of a clear filtrate. If, in the course of time, the density of the filter cake layer is gradually increased by the deposition of fine material such that its filtering capacity is decreased, then the layer should be removed and measures for this included in the working programme. Therefore in the scraper centrifuge the filter proper is only of secondary importance. It serves just as a support for the filter layer formed by the solid material.

The filter is fixed into modern machines simply by clamping it in the basket between grooves and holding it in place by rubber cords. Thus the filter can be changed easily and quickly.

The modern scraper centrifuge is an easily accessible unit chiefly because of the overhung arrangement of the basket, with the front of the machine designed as a door behind which the operating mechanisms are fitted. After opening the door all parts are freely accessible. The scraper devices can also be actuated when the machine is open.

The design of the scraper centrifuge is such that a gas-tight model can be constructed with little modification. In addition, branches are provided so that, when necessary, the centrifuge can be run at pressures below atmospheric or with special gases. It can also be constructed with heating or cooling facilities.

As the scraper centrifuge, in addition to the push-type centrifuge described below, is particularly suitable for the processing of granular materials difficult to filter and since the percentage of liquid remaining in the centrifuged material is relatively high centrifuging must also often be followed by washing to remove or separate the mother liquor, according to whether recovery of a pure solid or of the mother liquor is desired. Naturally washing is carried out at full speed and the machine is suitably fitted with spray pipes or similar parts. Washing can be repeated several times or be carried out with various liquids.

If, for example, it is required to lead the mother liquor and washing liquid away separately, valves or flaps can be fitted to the discharge branches. Like the feed and scraper devices, the wash valves and flaps are hydraulically operated.

The scraper centrifuge, however, is not only used as a filter, as already indicated, but as a separator. There are many instances of its application to the separation of liquids and solids into their various constituents, these solids being impossible to filter. For instance, it can be used for colloidal slurries, pastes, amorphous materials, etc. Even thin layers of such materials are impermeable to liquids. In such cases the type of filter used is of no significance. Under these conditions separation takes place, according to the difference in specific weight. Most solids are relatively heavy so that within a given time they are precipitated by centrifugal force on to the basket wall. The lighter weight liquids are separated out above. The separation centrifugals are fitted with non-perforated baskets. These are discharged by means of the previously mentioned scoop pipes through which the liquids are taken off, again at full speed. Even in this case the different liquids can be discharged in their separate constituents, for instance, by means of valves. The precipitated solids are again removed by means of the standard scrapers.

One special type of the centrifuge is the overflow machine. This also has a non-perforated basket but is only used when handling non-filtrable, but rapidly separating materials. In this case the material is fed in at the back and forced to flow over the whole width. The throughput time is sufficient to precipitate the solids so that the liquid running over the edge of the basket is practically clear. The machine is unloaded when the basket has been filled to a certain extent, again by means of scoops and scrapers.

At this point the difference between the filter centrifugal and the separator centrifugal should be noted. Whereas a filtrable product after centrifuging has a liquid content of the order of about 3-15%, the value is considerably higher in the separation process. It may amount to as much as 50-90%. This is because in separation the liquid trapped between the individual particles cannot be freed and these particles are separated from one another by a film of liquid, the thickness of which can be significantly large in comparison with the dimensions of the particles themselves. It should also be noted that even under favourable conditions, *i.e.* when the particles are formed from spheres of equal dimensions and these are arranged as close as possible, the space between amounts to about 25% of the total volume.

With a filtrable material it is possible to utilise practically the whole of the capacity of the basket for the solid material, whereas with a non-filtrable material the separated liquid also takes up part of the capacity. Thus the centrifuge with a non-perforated basket is sometimes less economical in operation. Of all the types of scraper machines the filter centrifuge is thus most commonly used.

The separate mechanisms are actuated, as mentioned, by hydraulic servo-motors which are controlled by a control unit comprising essentially a motor-driven pump set, a valve set and a sequence switch. Arranged as one control unit and complete with oil storage vessel, these are located inside the stator of the machine. By actuating the sequence switch the separate mechanisms can be switched in and out in the desired sequence, incorrect switching being impossible. As a rule, the basket is loaded and unloaded in accordance with the progress of the operation itself, whereas washing and centrifuging are effected according to the times required.

With this manner of operation the attendant need only check the state of a machine periodically and for a very short time. One operator can thus, without difficulty, control a whole series of centrifuges or, in fact, take charge of the whole plant.

In addition, automatic controls have been developed which practically eliminate the need for human control and provide most sensitive regulation and adjustment. However, practical experience has shown that the prerequisites for fully automatic operation of centrifuges are seldom fulfilled. Variations in the centrifugal properties of materials in chemical processes are much too frequent for a fixed schedule to be followed for a long time. When the single operation times have to be adjusted too often in the control apparatus, and this must be done manually, then the operation is no longer fully automatic. The above described semi-automatic operation is by far the most suitable.

The parts of the scraper centrifuge in contact with the material to be processed must be constructed from suitable materials, in particular when used in the chemical industries. The most common steel used is the alloy 316, containing about 18% chrome, 12% nickel and 2-3% molybdenum. In the modern designs, the casings, doors, baskets, scraper devices, chutes, feed valves, etc., are made entirely of this alloy. The mere lining of the machine with alloy sheet ultimately results in corrosion and is also not satisfactory as regards erosion. Frequently rubber and synthetic resins have sufficient chemical resistance and can be used as linings.

Experience has also shown that for the exacting duty which is usually encountered, the comprehensive unit type centrifuge is the most suitable. With these, the motors, belt drives, braking and control mechanisms are all built inside the stator of the machine. Fig. 1 illustrates this type of unit. By suitable arrangement of the covers, doors, etc., all parts are easily accessible at any time. Fig. 2 shows its working phases.

Modern scraper centrifuges are robust

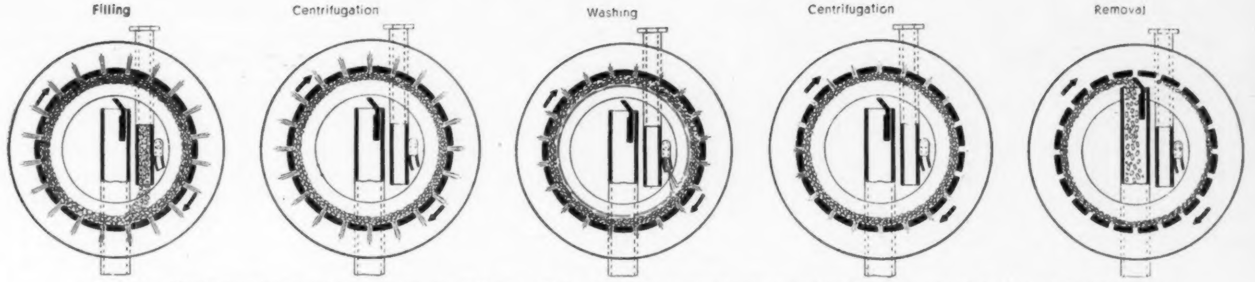


Fig. 2. Working phases of a scraper centrifuge. This machine is particularly suitable for materials not easily filtered.

but simply made and are adaptable to difficult operating conditions.

They are built in a wide range of sizes from laboratory models to large industrial machines. The laboratory model has a basket diameter of 400 mm. and an effective capacity of about 7 litres, whereas the largest industrial type has a basket diameter of 2 x 2,600 mm. and an aggregate capacity of about 4,000 l. In this latter case it is a double machine in which the baskets are arranged back to back on the same shaft. The potential applications of this type are somewhat limited, however. They are, of course, able to deal with considerable outputs because of the large basket volumes, but this adversely affects the residual liquid in the centrifuged material and the specific power consumption. In fact, the centrifugal force developed is proportional to the square of the speed (r.p.m.), whereas the circumferential velocity is only directly proportional to it. In determining the efficiency of operation the question always arises as to whether it is better to use one large unit or a series of smaller centrifuges for a given capacity. In most cases the medium-size types of about 1,000-1,300 mm. basket diameter provide the best arrangements.

The preceding indicates the already appreciable advantages of the scraper centrifuge over the vertical machine. Its field of applications are thus correspondingly wide.

Despite constant rotor speed during all operations the running of a scraper centrifuge is essentially discontinuous, in that the individual operations are repeated at given intervals. Hence, it does not satisfy all requirements and interested parties have investigated further the development of a continuous centrifuge. With a truly continuous machine it is understood that the material is fed into the centrifuge continuously and the separated constituents discharged continuously.

Screw-type centrifuge

The screw-type centrifuge is one of the oldest designs and published descriptions and patent applications date back for more than a hundred years. It is known as the screw-type centrifuge because the solids precipitated in the basket are continuously removed by means of a screw or worm. In most cases the worms are fitted inside the basket and arranged concentrically with the shaft so that they have a velocity relative to the basket. This difference in the speeds of the basket and the worm is created by means of differential drives, by gear wheels, and so on. According to its size and purpose, this centrifuge is designed with either a horizontal or vertical shaft. The number of threads on the worm, their height and pitch is dependant on the product handled.

The horizontal machine is suitable for sludges, *i.e.* non-filtrable products, and the basket and worms are tapered off from the input to the output side. The basket has no filter as the separation is effected by the differences in specific gravities of the constituents.

Smaller models and units for the processing of filtrable materials, for example, salts, are chiefly built with vertical axes. In addition, the solid material passes from the smaller to the larger diameter part of the basket. The inlet is usually at the top, so that the product removed by the worm is discharged downwards. The filter lining is generally formed of perforated or grooved sheets and the worms are again designed to suit the specific materials.

Assuming that the worm-type centrifuge operates perfectly continuously, the throughputs attainable for suitable materials are quite considerable. Moreover, since the greater part of the liquid is already removed at the smaller diameter section of the basket and must therefore be accelerated to a lesser extent, and as the basket increases in diameter towards the output end, the power requirements of the vertical model are comparatively low.

The worm conveyance and the conical shaped basket facilitate centrifuging of the liquid because the solid is shaken about and disrupted during its path through the machine.

On the other hand, this action not only produces considerable friction between the separate particles but these slide the whole length of the worm and along the filter covering. Since, in addition to the increased wear on the filter and the worm, the particles are also wedged between the two parts of the machines which are rotating at different speeds, appreciable disintegration of the particles often occurs. Moreover, as client's specifications often require that such disintegration shall not occur, the application of the screw-type centrifuge is limited.

The machine is also limited in size on account of the differential drives which have to be incorporated in the unit. A further disadvantage is that it is difficult and in some instances impossible to wash the material in the machine.

Apart from the fact that the washing mechanism can hardly be fitted in the space available for centrifuging, the greater part of the washing liquid flows directly through the filter because this is only partly covered with the material, namely, on the delivery side of the worm.

In spite of these disadvantages, the worm centrifuge has many applications and during recent years it has been used on an increasing scale.

Push-type centrifuge

The push-type centrifuge is a continuously operating machine in which the material is pushed through the basket and out of the machine.

The pushing principle has long been known and was already being used during the latter half of the last century. Then, however, it was used for discontinuous operation inasmuch as the pushing discs only came into action after centrifuging.

The application of the pusher in a continuous operation dates back to 1908 and is credited to Eckstein. Many years passed, however, before the development was applied practically. In 1930, Escher Wyss Ltd., of Zurich, took up the development of this system. After overcoming inevitable difficulties, the Escher Wyss push-type centrifuge was constructed for a wide range of materials and uses, and there are already several hundred such machines in service. Interest has increased even more since it was found that otherwise insoluble problems could be overcome by means of the push-type centrifuge. Today no difficulties are encountered in handling materials ranging from several hundredths of a millimeter in particle size to 40 mm. length in these machines. Even relatively viscous mixtures, for which only the vertical centrifuge could previously be employed, can now be successfully separated in push-type centrifuges of not inappreciable capacities.

The basic construction of the push-type centrifuge is shown in the diagram in Fig. 3. Generally it is constructed with a horizontal axis and the basket is overhung, so as to ensure easy access to the production

side as well as to the mechanical parts. The basket is fitted with sieves. Whereas it is open on the front side, the back is formed by a pusher disc which moves axially backwards and forwards. For this purpose the pusher disc is connected by a piston rod and piston to a hydraulic control system operating continuously under oil pressure.

The speeds of the basket and pushing mechanism are synchronised. The basket is surrounded by a housing in two parts, one of which takes the separated liquid and the other the solids. A funnel is built on to the pusher disc. The material to be centrifuged, for example, salt/brine solution, flows through the inlet pipe into this funnel where it is successively accelerated and then uniformly fed into the centrifuge basket.

When the material reaches the sieve covering, the greater part of the liquid is quickly separated but the solids retained. As a result of the continuous backwards and forwards motion of the pusher, the solid material is pushed successively forward in the direction of the basket opening, and the space formed between the solids, which have been advanced, and the pusher, which has retreated, is immediately filled again with further incoming material. Thus the centrally arranged input funnel acts both as a buffer during the working stroke and as a metering device during the back stroke. It continuously limits the thickness of the layer of solid material so that this remains uniform over the whole length of the basket. This ensures balanced, vibration-free running of the rotating parts.

The length of the basket is such that, on the one hand, the resistance to the pushing out is maintained within permissible limits while, on the other, enough time is allowed for adequate separation of the liquid from the material. The thickness of the layer of solid material and hence the calibrating diameter of the inlet funnel depend on the material to be handled. The more difficult the material is to filter, the thinner this layer must be maintained in order to separate the liquid in the available processing time. The same applies to the centrifuging of viscous materials which also restrain the filtering process.

From these descriptions, two significant advantages of this kind of centrifuge over other types are clear. The material flowing into the machine always comes into contact with an almost free sieve surface so that the layer of material through which the liquid has to pass is always thin, the greater part of the liquid thus being separated off very quickly.

The thickness of the deposited cake can always be adjusted to the prevailing conditions, and in addition be kept small, which also has a favourable effect on the centrifugation process, *i.e.* it is carried out more rapidly.

The filter is important. It must be made so that, while having a maximum filtering surface, minimum resistance is offered to the pushing of the material. The conventional filters, such as wire mesh and cloth filters, are not suitable. Not only would their resistance to the advancing material prove too large but their mechanical strength is insufficient and the pushing power of the machines would tear these filters apart in a very short time. The push-type centrifuge is thus fitted with special filter screens developed by Escher Wyss. Essentially these comprise strong metal bars which are arranged parallel to the basket axis and a certain distance apart, depending on the material being processed. The slits thus formed increase in width in the outward direction; they are machined, *i.e.* accurately dimensioned, and spread out over the whole of the length of the basket.

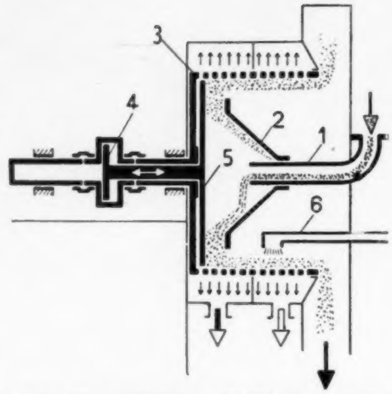


Fig. 3. The push-type centrifuge. (1) Inlet. (2) Inlet funnel. (3) Basket. (4) Servo-motor piston. (5) Pusher disc. (6) Washing spray.

Through the machining of such screens it is possible to use a wide range of materials of any thickness and hence these special filter screens have a life of several years in many instances. The arrangement of the filter slits parallel to the axis and the fact that the coefficient of friction is lower between the filter and the particles, than between the particles themselves, automatically produces a high self-cleaning effect. The solid material slides effectively over the metal bars, removing particles eventually trapped in the slits or pressing them through.

As the material is passed through the basket parallel to the axis, *i.e.* along the shortest path, and as only a small proportion actually comes into contact with the sieve, practically none of the particles are disintegrated. This is also a considerable advantage of the push-type centrifuge and the machine thus meets to a large degree the stringent requirements of industry.

The throughputs attainable with the centrifuge are considerable, which is understandable considering the simple, ideal mode of operation. The largest machine constructed to date has a throughput of at least 30 metric tons/hr. of centrifuged material. This amount, of course, depends on the specific centrifugation properties of the material, but nevertheless it is always considerably greater than with other types of centrifuge of the same dimensions. In addition, regulation of this capacity is very simple, inasmuch as it is controlled by adjusting the rate of feed. The pushing mechanism of the machine continuously executes its maximum number of strokes, but, of course, pushes only as much material out as is fed into the machine. Thus only the effective stroke of this layer is changed, whereas the actual thickness of the layer remains constant. The machine is thus capable of producing any desired yield within its maximum rated capacity always with the same cake formation.

In addition, the hydraulic operation of the pusher mechanism ensures flexible operation which avoids overloading of any of the working parts. At the same time the parts moving within one another are always properly lubricated so that the machine not only operates automatically but requires practically no attendance.

In the push-type centrifuge the material can also be washed continuously by appropriate sprays. As shown in the diagram, the position of the washing mechanisms can be altered as desired during operation so that the requirements of the end products may be met in a simple manner. By employing a number of sprays arranged one behind the other, it is also possible to repeat the washing process or to wash the material with different liquids. The division of the centrifuge housing into different chambers with separate outlets facilitates separation of the liquids into their respective components. This is further assisted in many cases by the incorporation of separation walls, the position of which can be adjusted. As the solid cake always has the same compactness, the washing operation can be carried out with minimum quantities of washing liquid.

As already mentioned, the machine is clearly divided into production and mechanical sections by the horizontal arrangement of the shaft. All working parts are inside the machine, thus protecting them against dust, spray water, vapours, etc. They are at the same time easily accessible since doors and covers have been provided wherever necessary.

The same applies to the production side of the machine, the large door at the front being the main item. By opening this, all the feed mechanisms, basket, pusher disc, sieve covering, etc., are accessible.

The control equipment chiefly comprises the oil storage tank, motor-driven pump set and control mechanism. Stuffing boxes, regulating valves and so on are completely dispensed with. The control works automatically with simple mechanisms. The various parts are located within the non-rotating section, the lower part of which is formed by the oil storage tank. The oil flows through a closed circuit back into this tank. Machines which are erected in surroundings at elevated tem-

peratures are fitted with cooling devices which regulate the temperature of the oil.

The parts of the push-type centrifuge in contact with the material being centrifuged are made of special materials, such as chrome-nickel alloys, non-ferrous metals, etc., according to requirements. In many cases vulcanised rubber, lead, plastic or other linings are used. The use of any alloys is possible because practically all the parts of the machine are made of simple cast units. This flexibility in the choice of materials is important as new steels are continually being produced.

The many applications of the push-type centrifuge have already been stressed. In practice all materials, the particles of which are at least several hundredths of a millimeter large and of suitable structure, and from which the liquid is not excessively viscous, can be treated in this machine. In addition to granular products it is also suitable for fibrous materials. A few of the typical products for which it is suitable are: fertiliser salts, table salt, borax, Glauber salt, sodium bicarbonate, copper sulphate, nickel sulphate, ferrous sulphate, coal slurries, nitro-cellulose, cellulose acetate, etc. Even such erosive materials as sand, metal filings, etc., can be processed. One of the more recent applications is for sugar which alone will open up a large new market. The Swiss Rhine Salt Works are also equipped with push-type centrifuges.

In keeping with the continuous operation of the push-type centrifuge, special importance is attached to suitable charging. It must not only be continuous but also of suitable concentration for centrifuging. Use of material of a certain minimum content of solid matter not only ensures good centrifugal action by the machine but it increases the attainable throughput and dryness of the centrifuged material. In addition, it reduces the power consumption of the unit, since in this case the weight to be accelerated is lower. Since these conditions and requirements are seldom fulfilled, suitable ancillary equipment for centrifuges has been developed by Escher Wyss. These include storage vessels, thickeners, feed regulating and metering units, etc.

A push-type centrifuge is shown in Fig. 4. The material coming from the plant first passes through a static thickener in which the solid material is precipitated by gravitational forces alone while the clarified liquid is returned directly to the process. The medium thick liquor is fed into the push-type centrifuge by a metering device.

It is recommended, in particular in the centrifugation of fine granular material, that the liquid separated off in the centrifuge be pumped back into the thickener so that any solid material which has passed through the sieve in the basket can be recovered by the thickener. With this arrangement the centrifuge delivers only the solid material and the liquid components are supplied from the thickener. By appropriate arrangement it is also possible to vary and adjust the concentration of the mixture to be centrifuged.

Fig. 4. Push-type centrifuge for industrial salts.

Storage vessels, thickeners, dosing devices, pumps, control gear, etc., are, in case of need, also made of the same special materials as the centrifuge itself. In the chemical industry it is often possible to use existing apparatus, *e.g.* saturators, crystallisers, etc., as storage vessels and thickeners, and to fit the control and metering devices direct to them.

The compact design of the push-type centrifuge and its ancillary equipment makes it a neatly arranged and easily accessible unit. At the same time it is economical in operation by virtue of high throughput, low uniform power consumption and automatic continuous operation.

Synthetic sapphire

Sapphire is used to make bearings in precision instruments. All high-grade watches and electrical instruments contain jewel bearings for efficient operation. The material chosen to make these bearings must be hard, the surface must have as low a coefficient of friction as possible and yet it must still be possible to work the material into the intricate shapes required. Sapphire possesses all these properties and is therefore an ideal choice.

The finished jewels required for use in instruments are usually in the shape of tiny cylinders with a cup in one end. Synthetic sapphires were previously produced in the form of 'boules,' small carrot-shaped stones weighing about 2 oz. The cylindrical 'blanks' from which bearing jewels are made were then cut from such a boule by a series of slicing operations using a wheel with a diamond edge. Since this lead to a considerable wastage of material, a process was developed whereby the sapphire is grown in the form of a rod that need only be sliced in one direction to give the tiny cylinders required.

There is a wide variety of other uses for the material in rod form, including styli for recording purposes, gramophone needles and thread or wire guides used in industry.

At the recent Royal Society Conversazione in London, workers from the General Electric Co.'s research laboratories gave a demonstration of the growth of sapphire rods in a small furnace. Fine alumina powder drops through an oxy-hydrogen flame and the resulting fine 'rain' of molten globules falls on the white hot tip of the rod which, on consequence, slowly grows in an upward direction. As the tip grows the rod is automatically withdrawn downwards so that the growing surface always remains in the same position in the furnace.

Examples of synthetic sapphire, ruby, spinel and rutile were shown.

Radioactive tracers for research on diffusional operations

Research work carried out by H. E. Hughes and J. O. Maloney of the University of Kansas, U.S.A., was undertaken to demonstrate the applicability of the tracer, carbon-14, to chemical engineering investigations, particularly in the field of diffusional operations, and also, if possible, to develop simpler methods of assaying liquid samples containing the isotope.

Four major investigations were carried out, three of which are described in *Chemical Engineering Progress*, 1952, **48**, (4), 192-200. All the investigations were related to the principal objective, but each had its own well-defined aims and problems. The first investigation resulted in the successful development of a new simple device for 'counting' the radioactive emissions from liquid samples which contain C-14. Two types of this device, one counter for use upon static samples, and one capable of continuously monitoring a liquid stream, were developed.

In the second study a modified Othmer still was used to obtain vapour-liquid equilibrium data on the systems methanol-water and methanol-ethanol. The methanol-water study demonstrated the applicability of the tracer method to this type of investigation. The next application of the tracer technique was to liquid-liquid equilibrium data. The system methanol-*n*-butanol-water was studied at 30°C. and at a pressure of 1 atm.; radioactive methanol counts and density determination were used for sample analyses. Complete component distribution and solubility data were obtained. Finally the tracer technique was applied to a study of a ternary system, methanol-ethanol-water, in a fractionation column.

The Practical Design of a Tube Still

By J. McLaren, B.Sc., F.R.I.C., A.R.T.C.

THIS article, while not purporting to describe the most accurate method of designing a tube still, gives a method using the equation of Wilson, *et al.*,[1] which has proved itself in the practical design of a light oil still.

The design of a tube still is a particular case of the general problem of heat transfer in a combustion chamber, which is one of the most complex problems of heat transmission. There are two methods of tackling the problem of transferring heat by radiation. The first and most scientific is the use of theoretical equations developed in any dissertation on heat transfer, *e.g.* 'Heat Transmission,' by McAdams.[2] The solution of these equations entails the use of trial-and-error calculations into which factors depending on the shape of the combustion chamber and the flame characteristics enter. As can be imagined, the solution of the problem by such a method is very laborious and time consuming.

The second method depends on the applicability of the empirical equation developed by Wilson, *et al.*,[1] namely

$$\mu = \frac{1}{1 + \dfrac{G\sqrt{Q\alpha Acp}}{4{,}200}} \qquad (1)$$

where μ = fraction of total heat in fuel absorbed by cold surface in combustion chamber;
G = lb. air/lb. fuel burnt;
α = fraction of radiant heat absorbed by tube surface as compared to that received by the plane replacing them;
Acp = area of plane in which tube rows lie, sq. ft.; and
Q = total heat input to combustion chamber in fuel, B.Th.U./hr.

This equation was developed from that of Orrock,[3] who analysed the results obtained from the investigation of the performance of boiler tube furnaces. Wilson, *et al.*, developed their modification of Orrock's equation after analysing results of 62 tests on 12 different types of tube still furnaces with the tubes arranged in rows on the roof and walls. The results obtained by using equation (1) gave results which were about 3% lower than those found from actual stills, but this is within the accuracy of the data usually available.

It is the second method of calculation which was used in the design of the tube still which is given in this article. The design usually commences with the determination of the shape of the still. This is automatically fixed by the use of the second method of calculation, since the equation used was developed empirically from results obtained from cubical or approximately cubical tube stills, and it would be unsafe to deviate radically from this shape in using equation (1) to design a proposed still. The normal tube still usually incorporates radiation and convection sections, the former being separated from the latter by a bridge wall at right-angles to the flame so that the tubes comprising the convection cannot 'see' the flame in the combustion chamber. This is accomplished by packing them in the space between the bridge wall and the back of the furnace. The heat transfer to the convection section may be determined by the equation:

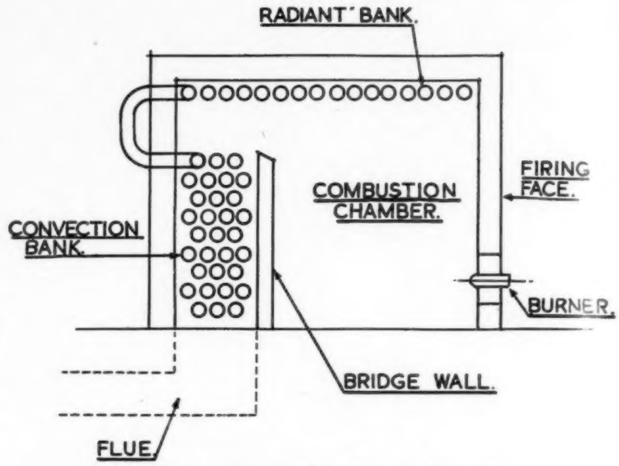
$$H = 2.38\,(F + 0.975) \text{ B.Th.U./sq.ft. hr. °F.} \qquad (2)$$

(overall coefficient)

where F = flue gas rate, thousands of lb./sq.ft. hr.

Of course, it should be realised that, where the major heat transfer is by radiation, a certain transference of heat also occurs by convection and *vice versa*, but the amounts transferred in each case by the alternative method may be neglected in practical calculations.

The tubes to receive radiant heat may be situated on the walls, roof and, in certain types of still, on the floor of the combustion chamber. In the example given below, of a simple type of still, the radiant tubes are situated in the roof only. In the convection section, smooth or gilled tubes may be used, but no great advantage is obtained by using the latter, as the tubes have to be spaced on larger centres and hence F in equation (2) becomes very small. Also with certain types of fuel, *e.g.* solid fuels and coal tar pitch, fly ash tends to become lodged in the spaces between the gills and thus forms an insulating layer over the major area of the tube used for heat transference.



Diagrammatic sketch of the tube still.

Before proceeding with the calculation for the design, using equation (1), it is essential that the outside diameter of the tubes which are to form the radiation section be determined, also the spacing of the tubes and the number of rows, because the term αAcp is dependent on those factors. The diameter of the tubes is determined by the nature of the liquid flowing in them and the percentage evaporation. These points are very important since, if the internal diameter of the tubes is too small, excessive pressures may be developed in the tubes and superheating of the fluid flowing in the tubes will occur. The latter effect, with thermally unstable fluids such as coal tar, can lead to excessive coke formation in the tubes. This may make the operation of the still uneconomical, since it results in excessive off-stream time for de-coking.

Other factors which influence coke formation are the heat transfer rate H B.Th.U./sq.ft. hr. chosen and also the temperature of the flue gases passing over the bridge wall, as well as the heat liberated/combustion chamber volume ratio. The values of H usually used vary between 5,000 and 15,000 B.Th.U./sq.ft. hr.; for coal tar it has been suggested that 6,000 B.Th.U./sq.ft. hr. and a bridge wall temperature of between 1,000 and 1,200°F. be used. It is usual to have a heat liberation of between 2,000 and 3,000 B.Th.U./cu.ft. hr. in the combustion chamber.

As mentioned above, the pressure in the radiation tubes is a critical feature in the design of tube stills handling thermally unstable fluids. This has been examined by Baars.[4] This point was also examined mathematically by the author in co-operation with R. Scott and it was shown that the pressure developed in a tube still and the actual point in the tubes where superheating commences may be determined. The development of the latter method is described by R. Scott.[5]

In the following example of the use of the Wilson, Lobo and Hottel equation the calculation is based on the design of a tube still for a continuous light oil distillation plant.

Example

Heat to be supplied to base of distillation column = 4,385,000 B.Th.U./hr.
Tube still setting loss = 15% of heat in fuel
Stack loss (heat in flue gas leaving convection section) = 15% of heat in fuel
Heat to combustion chamber
= 4,385,000/0.7 = 6,260,000 B.Th.U./hr.
CO_2 in stack gas = $11\frac{1}{2}$% by vol.
∴ Temperature of flue gas leaving still = 600°F.
∴ Excess air in flue gas = 60% of theoretical air
The fuel used is coal tar pitch.
Theoretical air = 12.059 lb./lb. fuel
∴ With 60% excess air = 19.4 lb./lb. fuel
∴ Flue gas = 19.4 + 1 = 20.4 lb./lb. fuel
Calorific value of fuel = 16,000 B.Th.U./lb.
∴ Fuel/hr. = 6,260,000/16,000 = 391 lb.
∴ Air/hr. = 391 × 19.4 = 7,590 lb.
∴ Flue gas/hr. = 391 × 20.4 = 7,980 lb.

Design of radiant section

Let the tubes forming the radiant section be in the form of a single row suspended from the roof. The theoretical inside diameter of the tube was not calculated but chosen because this diameter of tube was available when no other size of stainless-steel tube could be obtained. Experience with previous tube stills had shown that the pressure development in the chosen tubes would not be too large, although conditions were slightly different from those under which previous tube stills had functioned. The tubes were spaced parallel with their centres $4\frac{3}{4}$ in. apart, and the outside diameter of each tube was $2\frac{1}{2}$ in.

Now let A = total surface area of exposed tubes, sq. ft.;
Acp = area of plane in which exposed tubes lie and by which the plane is bounded, sq. ft.;
L = length of exposed tubes, ft.;
H = heat transfer rate to exposed tubes, B.Th.U./sq.ft. hr.;
H' = heat transfer to Acp, B.Th.U./sq.ft.; and
α = fraction of radiant heat absorbed by tube surface as compared to that received by Acp.

$$\therefore A \times H = Acp \times \alpha \times H';$$
$$A = \pi \times 2.5/12 \text{ sq.ft./ft. length of tube};$$
$$H = 9{,}000 \text{ B.Th.U./sq.ft. hr., chosen from experience};$$
$$Acp = 4.75/12 \text{ sq.ft./ft. length of tube; and}$$
$$\alpha = \frac{\text{centre to centre distance between adjacent tubes}}{\text{outside diameter of one tube}}$$
$$= \frac{4.75}{2.5}$$
$$= 1.9.$$

Now, referring to Fig. 6 on p. 58 of 'Heat Transmission,' by McAdams, curve for single-row roof, it is found that

$$\alpha = 0.88$$
$$\mu = \frac{1}{1 + \dfrac{G\sqrt{Q/Acp\,\alpha}}{4{,}200}}$$

Where the symbols are as explained previously
G = 19.4 lb. air/lb. fuel fired
Q = 6,260,000 B.Th.U./hr.

This equation may be modified as follows:

$$A \times H = Acp \times \alpha \times H'$$
$$\therefore H' = \frac{A \times H}{\alpha \times Acp}$$
$$= \frac{\pi \times 2.5 \times 9{,}000}{0.88 \times 4.75}$$
$$= 16{,}900 \text{ B.Th.U./sq.ft. hr.}$$
$$\text{but } \mu \times Q = H' \times \alpha \times Acp$$
$$\therefore \alpha Acp = \mu \times Q/H'$$
$$\therefore \mu = \frac{1}{1 \times \dfrac{G\sqrt{H'/\mu}}{4{,}200}}$$
$$\therefore 4{,}200\mu + G\sqrt{H' \times \mu} = 4{,}200$$
$$\therefore \mu + \frac{G\sqrt{H' \times \mu}}{4{,}200} - 1 = 0$$
$$\therefore \mu + \frac{19.4 \times \sqrt{16{,}900 \times \mu}}{4{,}200} - 1 = 0$$
$$\therefore \mu + 0.6\sqrt{\mu} - 1 = 0$$
$$\therefore \sqrt{\mu} = \frac{-0.6 \pm \sqrt{0.36 + 4}}{2}$$
$$= \frac{-0.6 \pm 2.09}{2}$$
$$= \frac{1.49}{2} \text{ neglecting negative values}$$
$$= 0.745$$
$$\therefore \mu = 0.555, \text{ say } 0.56.$$

This result could have been found more readily from the article by R. Scott[5] (p. 12, Fig. 6), but it is calculated here to illustrate more fully the use of equation (1):

∴ Heat absorbed by radiant bank
= 0.56 × 6,260,000 = 3,500,000 B.Th.U./hr.
Rate of heat absorption = 9,000 B.Th.U./hr.
∴ Area of radiant bank
= 3,500,000/900 = 389 sq. ft.
Overall diameter of tube = $2\frac{1}{2}$ in.
Length of tube required
= 12 × 389/(π × 2.5) = 595 ft.
Length of individual tubes = 15 ft.
∴ No. tubes = 595/15 = 40.

In the case of coal tar pitch, rather a large volume of combustion chamber is necessary to ensure complete combustion of the fuel, 2,000 B.Th.U. heat liberated/cu.ft. of combustion chamber volume

∴ Volume of combustion chamber = 6,260,000/2,000 = 3,130 cu. ft.

Length of tubes = 15 ft.

$$\text{Breadth of furnace} = \frac{40 \times 4.75}{12} + \frac{2.5 + 6}{12} \text{ ft.}$$

Where $2\frac{1}{2}$ in. = sum of distances from centres of end tubes to tube walls.
6 in. = sum of distances between end tubes and combustion chamber walls.

∴ Breadth of furnace = 15.8 ft. + 0.71 ft.
= 16.51 ft.
say 16 ft. 6 in.

$$\therefore \text{Height of combustion chamber} = \frac{3{,}130}{15 \times 16.5} = 12.65, \text{ say } 13 \text{ ft.}$$

Thus the main problem is solved.

The heat transferred in the convection section is then found by subtracting 3,500,000 B.Th.U./hr. from the total heat liberated in the combustion chamber less that lost by the setting. The total loss by the setting is 15% of the total heat liberated, but only four-fifths of this is lost in the combustion chamber proper, through the front, two sides and roof. The remaining fifth is lost through the back wall. Hence the heat in the flue gas passing over the bridge wall is equal to:

$$6{,}260{,}000 - 0.15 \times 0.8 - 3{,}500{,}000 = 2{,}009{,}000 \text{ B.Th.U./hr.}$$

(*Concluded on page 670*)

Ion-exchanger for Glycerin Purification

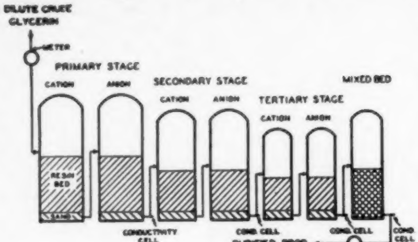
As sodium chloride comprises the bulk of the impurity which must be removed from crude glycerin in the purification process, ion-exchange has for some years been recognised as a means of accomplishing this end. In May 1951 the first commercial ion-exchange unit for the purification of soap-lye crude glycerin* was put into successful operation at the new Lever Bros. Co. plant in Los Angeles, California. This unit was designed by the Illinois Water Treatment Co. and was fabricated and installed under their supervision. The purification capacity of the plant is 26,600 lb./day of crude glycerin. Most important advantages over the conventional distillation method are said to be low capital investment, economy of operation and exceptionally high product quality.

The unit

The ion-exchanger, which was installed at Los Angeles, is a four-stage unit, consisting of three pairs of cation-anion exchangers and a mixed-bed, making a total of seven vessels which are arranged in series. Each of the primary exchangers has 4,460 gal. capacity and contains approximately 330 cu. ft. of resin. Each of the secondary vessels has 920 gal. capacity and contains 66 cu. ft. of resin. Each of the tertiary units has 206 gal. capacity and contains 12 cu. ft. of resin. The mixed-bed has a capacity of 350 gal. and contains 8 cu. ft. of cation-exchange resin and 16 cu. ft. of anion-exchange resin. In each of the first six exchangers the resin is supported by a bed of graded gravel.

All the exchanger vessels are of rubber-lined steel construction and were built to withstand pressure. They are cylindrical in shape and sized in such a manner that all will become exhausted and require regeneration at approximately the same time. Each exchanger vessel is equipped with two glass observation ports located near the centre of the side wall. These permit visual inspection of the resin

*Abstracted from *J. of the Amer. Oil Chemists Soc.*, 1952, **29**, (8), 318-320.



Ion-exchange unit for the purification of soap-lye crude glycerin.

surface and are used in connection with liquid-level control.

Influent lines to the cation exchangers are for dilute glycerin, raw water, dilute sulphuric acid regenerant and compressed air. Effluent lines are for the dilute product, clean and dirty water recovery, and

Analytical Data showing Typical Double-Distilled Glycerin and Ion-exchanged Glycerin

	Double-distilled	*Ion-exchanged*
Glycerol, % ..	95.14	99.30
Residue, % ..	0.0084	0.0070
Ash, % ..	0.0034	0.0006
NaCl, % ..	0.0007	0.0005
Fatty acids and esters* ..	4.50	4.90

*This is a back-titration figure. Sample is treated with 5.0 ml. of 0.5 N. NaOH, and back-titrated with 0.5 N. HCl. The fatty acids and esters are expressed in terms of ml. of 0.5 N. HCl.

waste to the sump. The anion exchangers are similarly equipped, except that treated or softened water is used in place of raw water, and dilute sodium hydroxide is used for regeneration instead of acid.

Radial-type distributors are located at the top, centre and bottom of each vessel. These handle the flow of liquid into and out of the tanks and are for the purpose of reducing turbulence and channelling.

All lines carrying partially de-ionised glycerin, acid or alkali are rubber lined, and all valves in the system are of the Saunders patent type. Flow is controlled by *Rotameters* and disc-type fluid meters.

The crude glycerin dilution tank has a capacity of 12,000 gal. and is fabricated of steel. The dilute product tank, which serves only as a relay vessel, is fabricated of stainless-clad steel.

Waste from the plant, which includes spent regenerant solutions containing sodium sulphate, sodium chloride, sulphuric acid, sodium hydroxide and organic colour and odour bodies, is run into a 12,000-gal. sump. Dirty water, obtained from backwashing the resin beds, and rinse waters containing sulphuric acid and sodium hydroxide, are also run into this sump. Since more acid than alkali is used for regeneration, the waste regenerants do not neutralise one another in the sump and it is necessary to add soda ash before discharging the waste to the sewer.

Synthetic resins

Five different synthetic resins are employed in the unit; the choice and location of each in the system are based upon particular exchange and adsorption characteristics. For example, the primary cation exchanger, into which is first introduced the dilute crude glycerin, contains a high capacity resin of the sulphonic-acid type. The primary anion exchanger contains a weak base, phenol formaldehyde resin, which has excellent colour adsorption characteristics.

The ion-exchange plant was designed to purify 26,000 lb./day of crude glycerin (82% glycerol) in two 12-hr. cycles, using 13,300 lb. of crude per cycle. A cycle includes dilution and purification of a batch of glycerin and the regeneration and preparation of the resins for further use. The impurities to be removed from crude glycerin are: sodium chloride, sodium sulphate, small amounts of calcium and magnesium from the water, traces of fatty acids and non-ionised colour and odour bodies.

The de-ionised glycerin solution is evaporated under vacuum to 95 to 99% glycerol. The fine product is exceptionally high in quality and does not require filtering or bleaching. It compares favourably with a high-grade distilled glycerin.

Tube Still (*Concluded from page 669*)

Specific heat of flue gas $= 0.23$ B.Th.U./hr. °F.
Flue gas/hr. $= 7{,}980$ lb.

$\therefore$ Temperature of gases passing over bridge wall

$$= 2{,}009{,}000/0.23 \times 7{,}980 = 1{,}100°F.$$

Exit temperature of flue gas from convection section $= 600°$F.

Now heat absorbed in the convection section

$$= 4{,}385{,}000 - 3{,}500{,}000 = 885{,}000 \text{ B.Th.U./hr.}$$

Hence, knowing the inlet temperature of the inlet liquid to the convection bank tubes, the exit temperature may be calculated in the usual manner. The length of tube in the convection bank is then calculated according to equation (2), but this will not be shown, as the main object of this article is to illustrate the design of a combustion chamber.

One point should be borne in mind in the design of the convection section. That is the provision of adequate means for the removal of fly ash from the tubes and the installation of holes in the brickwork of the back wall of the convection section for the introduction of steam lances to blow the ash from the surfaces of the tubes. The author knows of one tube still where the bridge wall had to be partly removed to clear fly ash from convection section tubes which was severely obstructing the flow of flue gas.

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RADIOCHEMICAL RESEARCH

Chemical Research Laboratory's New Building

The new Radiochemical Building at Teddington, Middlesex, completed last June, has been built as part of the post-war expansion programme of the Chemical Research Laboratory of the Department of Scientific and Industrial Research. It provides excellent facilities for the continuation of the C.R.L.'s radiochemical research on a larger scale than has hitherto been possible. The laboratory, which has a staff of 35, is mainly concerned with the analysis and processing of the rarer metals and radioactive minerals and ores. In general, the investigations are on a laboratory scale, pilot-plant development and commercial exploitation of new processes being left to outside interests. Here is a description of the building and of some of the work done there.

THE C.R.L.'s new Radiochemical Building, which was designed by the Ministry of Works, who also supervised construction, is a flat-roofed, single-storey structure about 208 ft. long covering an area of 12,000 sq. ft. Superficially it looks like any other modern chemical research laboratory, and it is only on close inspection that one sees the refinements in design and equipment made necessary by the potentially hazardous nature of the work done there. In fact, the building has been designed for 'hot' radiochemical work involving the handling of extremely radioactive materials. So far, however, radioactivity has been at a low level.

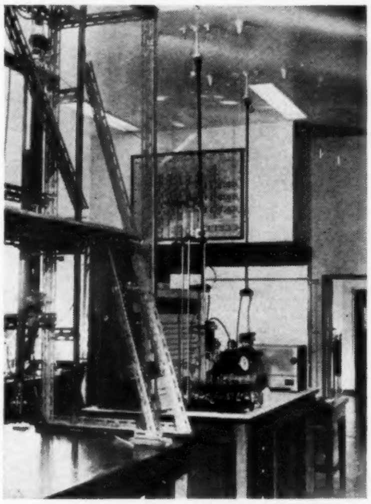
General layout

After passing through the small office block at the entrance, there are a number of small laboratories on either side of the central corridor where physico-chemical and radiometric investigations are carried out. In the centre of the building there is a large analytical laboratory spreading across the whole width of the block. At the end of the corridor there is a large concentration laboratory adjacent to which are smaller laboratories, a balance room and a grinding and ore preparation room.

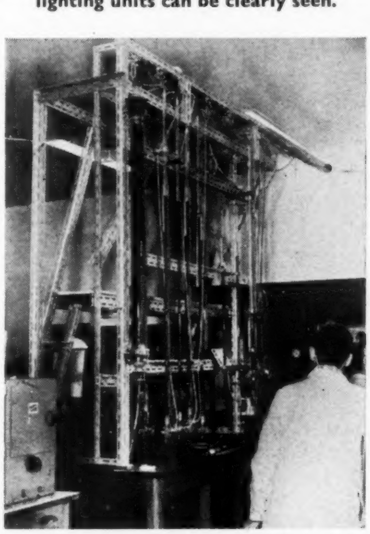
In the Plant Room, accessible only from the outside, there is an air-conditioning system for treating all incoming air, an electrostatic precipitation plant for treating atmospheric effluents, the steam boiler unit for supplying service steam and the steam-heated floor panels, and an air compressor.

All service pipelines and air ducts are arranged in a well laid-out pipe room above the laboratories. The delay tank farm and effluent pumps are located just outside the main block.

All drainage from the laboratories passes to the tank farm. As in the case of the atmospheric effluent facilities, there are two drainage systems. The water used for chemical work, which is more highly contaminated, passes through polythene piping to one of three specially designed delay tanks, where it is tested and can be stored, diluted or chemically treated if necessary. Other water passes to one of two larger tanks, where it is stored before disposal. All water, however, is tested to ensure that radioactivity is below specified limits before passing to the public drainage system.



Automatic constant volume fraction collector in the concentration laboratory. Electricity supply sockets fitted to the ceiling and the flush-mounted fluorescent lighting units can be clearly seen.



Glass apparatus for the separation and recovery of metals from solutions by ion-exchange. 'Dexion' alloy structure, shown here, is used a great deal in all the laboratories. The hole in the wall on the right leads to the service void and has been specially constructed to provide additional height for the gravity feed to the ion-exchange columns.

The upper windowless floor is used entirely for the numerous pipelines, clean and effluent air and the services, etc. All the pipework is clearly laid out over this floor, which is of concrete with a red-painted dust-resisting surface. The pipes are all painted in accordance with the colour code employed at the Atomic Energy Research Establishment laboratories at Harwell. The code is used throughout the building, and even the electrostatic precipitators for outgoing air are painted in yellow, designating them as 'hot.'

Laboratory services all pass through the floor down into the laboratories below and are easily accessible for maintenance.

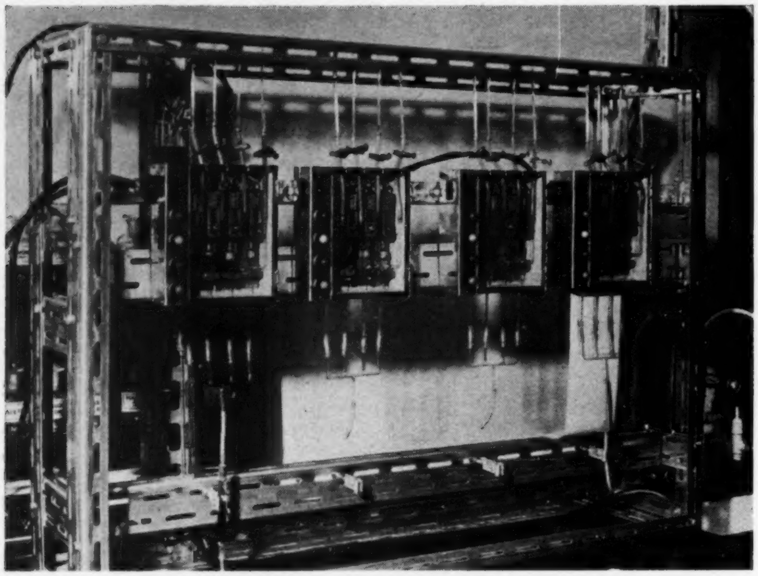
Fluorescent lighting units and the conditioned air inlets are also inserted from this floor and can thus be easily serviced or inspected without using ladders.

On this upper floor there is also a mains water storage tank which has been built above the laboratories chiefly to give a head of water.

Analytical laboratory

Work in the analytical section can be roughly divided into two: firstly, the analysis of ores containing rarer metals, such as gold, tantalum, thorium and niobium as well as uranium; secondly, research on new analytical methods.

In this work considerable use is made of chromatographic separation on cellulose columns, a method which has been pioneered by the Chemical Research Laboratory at Teddington. Analysis of minerals containing uranium by this method involves, broadly, the breakdown of the ore with hydrogen fluoride and nitric acid. It is then evaporated to dryness and leached with dilute nitric acid, after which it is extracted on a cellulose column with 5% ether nitric acid. The ether is distilled off and gravimetric, volumetric or colorimetric methods are employed to estimate the content. A glass column packed with activated cellulose pulp in organic solvent is used. An aqueous solution of the material for analysis is absorbed on to activated cellulose to form a wad which is transferred from the beaker to the top of the column. The wad



Automatic ion-exchange resin life tester.

Fume cupboard in one of the smaller concentration laboratories. The wall-mounted gas and other service inlets can be seen, as well as the external controls. The bottom tray is stainless steel and the side walls are an aluminium shell coated with 'Vinylite.' In the corner on the left is a balance room.

is then beaten up to form a continuous column. A solvent is passed through the column, one element moving down and the others being retained. One element is completely eluted in the final stage.

Work on solvent extraction methods, the measurement of fluorescence and inorganic chromatography employing the paper strip technique is also carried out.

Gold recovery

The recovery of gold from cyanide solutions by ion-exchange is being investigated. The method is a modification of the conventional cyanidation of the gold-bearing ore in which zinc precipitation has been replaced by ion-exchange using *Amberlite IRA* 400 as the ion-exchange resin. The gold is taken from the resin with the aid of organic solvents. This process has been patented.

Some members of the gold industry have already indicated their interest and commercial exploitation is likely later, since the method is claimed to have several advantages over the conventional one.

Concentration section

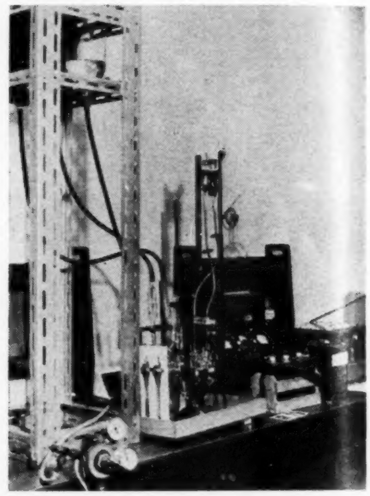
This section is developing methods for the concentration of rare metals from radioactive minerals and ores. There are a number of different teams working on specific ores in close liaison with other teams studying the fundamental chemistry of the process involved. This work is carried out in the large end laboratory.

The largest piece of apparatus used employs ion-exchange resins to separate metals. Other work includes precipitation under controlled *p*H, centrifugal separation and other methods.

Resin life tester

Ion-exchange methods are being used a great deal, and in order to determine the extent to which the capacity of an ion-exchange resin will change with use it is necessary to carry out a large number of adsorption and elution cycles and to measure periodically the resin capacity.

A resin tester has been designed to pass known quantities of each of four solutions automatically through four different ion-exchange columns. By means of suitable relay systems each resin is put through four cycles: adsorb, wash, elute

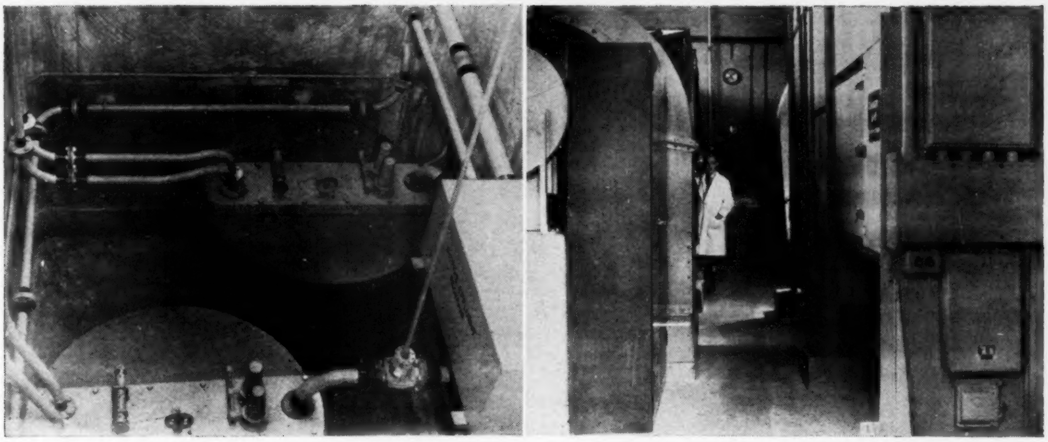


Continuous-recording polarograph for recording the metal concentration in a solution.

and wash. When this series of operations is complete in one column, the Post Office counter associated with that circuit moves on one unit and the sequence is repeated. It is thus only necessary to remove the column at intervals and measure the capacity, which may then be correlated with the number of cycles to which it has been subjected.

Continuous polarograph

This apparatus, which was designed at the laboratory, is used for the continuous determination of the metal concentration in a flowing solution by a polarographic method. A portion of the solution for measurement is taken continuously from the main flow, and after mixing with an appropriate base solution and removal of oxygen, it is passed through two polarographic cells with synchronised dropping mercury electrodes. The voltage of one electrode is set at the bottom of the polarographic wave for the metal ion and the voltage of the other electrode at the top of the wave. With a good wave form, the current difference flowing in the two cells gives a direct measure of the metal concentration in the solution at any time. This



(Left) **Two of the three active effluent delay tanks.** *(Right)* **In the Plant Room. The air purification plant is on the left and the electrostatic precipitator for treating the outgoing air before discharge to the atmosphere on the right**

current is amplified sufficiently to operate a pen recorder giving a permanent record.

Grinding room

Ore treatment equipment in the grinding room includes a ball mill, disintegrator, screening apparatus, magnetic separator and sampling equipment. Small samples on a scale up to 2-3 cwt. and up to 2 in. in size can be handled with this equipment.

This room has an air-extraction system separate from the rest of the building and designed to deal with the dust produced during grinding. The electrostatic precipitator in the roof room is, as mentioned, used to treat this air effluent.

Counting equipment, a scintillation counter for liquids, and apparatus for the measurement of radioactive carbon, C^{14}, are available in the radiometric laboratories.

Construction

The outer laboratory walls are of brick and plaster, but the inner walls are painted with a cream finish containing PVC and called *Vinylite*. The floor covering is polished linoleum in a pleasant shade of red. The ceiling is also painted with cream *Vinylite*.

All the laboratories have large double windows, the inner glass panes being fitted flush with the walls to produce smooth lines and thus eliminate crevices. The use of double windows also complies with the special ventilation requirements, as it prevents the ingress of air except through the air purification plant. At the same time it increases the efficiency of the space heating by eliminating draughts.

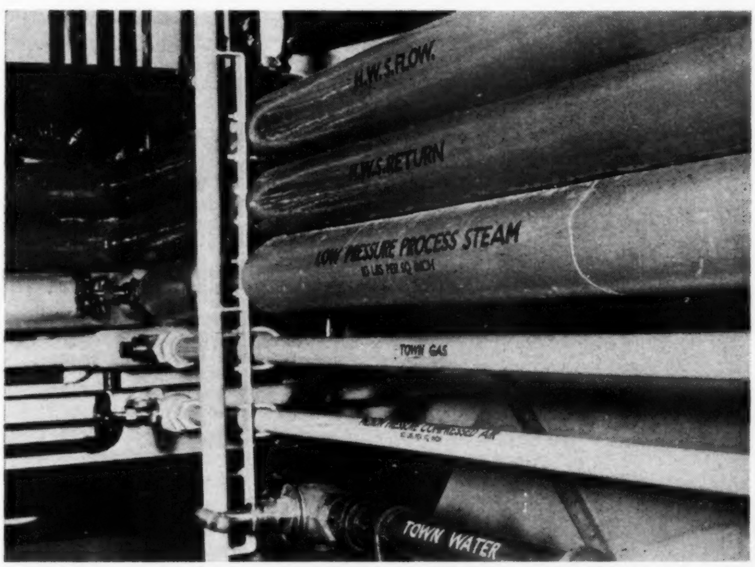
Fluorescent lighting is used throughout in the laboratories (except the counting room), and the units are mounted flush with the ceiling surface again to avoid unnecessary crevices and to provide the smooth finish necessary in a radiochemical laboratory.

Two space-heating systems are used simultaneously. There is normal central heating and in addition steam-heated panels below the floor surface. Radiators are used to heat offices and cloakrooms.

All laboratories have supplies of compressed air and steam in addition to water, gas and electricity. In some instances the electricity supply is taken from the ceiling so that tall apparatus can be built up from the bench below, or the bench can be removed and the apparatus built up from the floor.

Fume cupboards each have an inner shell of aluminium painted with cream *Vinylite* and a bottom tray of stainless steel with rounded corners for easy cleaning. The gas, steam, water and compressed air inlets are all arranged on the side walls and all controls are outside the cupboard. A removable lead brick wall can be inserted if 'hot' work is being carried out.

Airtight windows have been provided to ensure proper ventilation of the laboratories. All incoming air is filtered, washed and warmed. Clean air is pumped to the laboratories through vents in the ceiling and then extracted through the fume cupboards. This also improves the working conditions for the staff and provides a clean atmosphere for accurate investigations.



A corner of the service void. The Harwell colour code is used to identify the different pipes.

Effluent treatment plant

All outgoing air is treated in a large electrostatic precipitator in the Plant Room, where suspended dust particles are separated out. The cleaned air is then passed to the atmosphere through a stack after being tested for radioactivity. The unit is cleaned out regularly.

A second smaller unit in a small room on the roof has been designed specially for outgoing air from the grinding and ore preparation room, where the degree of contamination due to dust is greater than in the laboratories. Aluminium ducting is painted internally with *Vinylite* and externally with ordinary paint, according to the colour code (yellow) used for the outgoing air.

Australian Chemical and Engineering Research

A wide range of chemical and chemical engineering research is done by the Australian Commonwealth Scientific and Industrial Research Organisation, which has recently published its third annual report on work carried out up to the middle of last year. Substantial progress has been made on the many research projects started by the Division of Industrial Chemistry during the previous year. Below are brief details of the present investigations on chemical engineering, fuel technology, physical and organic chemistry, cement and ceramics, metallurgy and ore dressing and nuclear physics. Work described in the Organisation's first and second annual reports was summarised in the September 1950 and November 1951 issues of this journal.

THE Australian Commonwealth Scientific and Industrial Research Organisation comprises some 15 Divisions, which are the major establishments. These are further subdivided into Sections and there are also independent Sections. The headquarters and main laboratories of the Industrial Chemistry Division are in Melbourne and there are branch laboratories in Sydney, Adelaide and Perth.

CHEMICAL ENGINEERING

Applied and fundamental chemical engineering research has been continued with the object of obtaining design data for industrial operations and processes, particularly in the fields of adsorption, fluid properties, fine particles and the utilisation of low-rank coals.

Adsorption processes

Work has been continued on the development of a continuous fractionating process for the separation of the components of solutions by adsorption on carbon and other adsorbents. The investigations have been centred on the separation of antibiotic materials and the treatment of industrial effluents. Methods have been developed for obtaining continuous counter-current flow between the solid adsorbent phase and the solutions, and these methods have been applied to both continuous and batch fractionating processes. The successful operation of these fractionating procedures has required the development of new methods for accurately controlling and measuring small flow rates for both solids and liquids.

Fluid properties

The Section has continued investigations to determine precise liquid and vapour equilibrium concentrations for binary mixtures, and other physical properties of fluids, and the manner of their variation with change in temperature or pressure. In the former work values have been obtained for the binary system cyclohexane-nitrobenzene at 80°C. and 760 mm. pressure. Apparatus has been developed for equilibrium measurements on systems having high relative volatility. Equipment has also been constructed for the precise determination of heats of mixing.

Statistical mechanics has been used in a theoretical study to evaluate the thermodynamic functions, firstly for a one-dimensional array and subsequently for a three-dimensional array, of alcohol molecules in a binary mixture of an alcohol and a non-polar liquid. This theoretical study has given results which are similar to those obtained experimentally, and shows promise of providing a means of predicting the thermodynamic properties of solutions of this type. This work has formed part of the programme of the Section's recently established and well-equipped high-pressure laboratory at the University of Sydney, where a new method permitting greater precision has been developed for the determination of the second virial coefficients of gases. These coefficients represent the magnitude of the initial departure of gas from ideality and provide data for determining intermolecular forces. Values of the coefficients have been determined for chloromethane, fluoromethane, *cyclopropane* and *n*-butanol.

Equipment and methods have been developed for the study of the effects of solvation on the dipole moments of molecules in solvents of low dielectric constants. In this connection determinations have been made of the dielectric constant of ethylene over a range of high pressures and of solutions of chloromethane in ethylene as a solvent gas up to pressures of 500 atm. and at temperatures of 25°C. and 50°C.

Work has been initiated, and equipment designed and partly constructed, for the determination of Joule-Thomson coefficients for several gases. These determinations provide an alternative experimental route for the determination of second virial coefficients and of thermodynamic properties. By such determinations it is hoped to co-operate with overseas laboratories in the preparation of charts of thermodynamic properties of industrially important fluids and fluid mixtures.

The synthesis of certain minerals is being attempted at high pressures and temperatures.

Some work has been done on developing methods for studying the solubility of inorganic salts in gases subjected to high pressures. An investigation of the thermodynamic properties of ionic solutions has begun.

Fine particles

The separation of finely divided solids from either gas or liquid suspensions is a problem common to many industrial processes. The observed behaviour of beds of fine particles when flocculated or compacted can be related to industrial filtration problems. Results obtained from research with dilute suspensions have been applied in the design and construction of a centrifugal dust and mist separator, in which it is expected that small particles may be separated for a low power consumption.

FUELS

Low-grade coal

During the year the erection of the laboratory, workshop and office accommodation for the programme of research of the Chemical Engineering Section into the utilisation of Australia's low-grade coals was completed. At present, research is directed toward the development of methods for the complete gasification of Victorian brown coal for the production of gas suitable for the synthesis of liquid fuels and chemicals, and of gas of high calorific value suitable for distribution as town gas.

As a result of a preliminary investigation of the gasification of brown coal and brown-coal chars in a small-scale fluidised bed, a new fluid-bed gasification unit has been constructed which incorporates numerous improvements. It is hoped that this unit will provide quantitative data concerning the influence of the operating variables on the performance of fluid-bed gasification systems. Preliminary designs have also been prepared for a further pilot plant in which the effects of operating pressures of up to 20 atm. will be investigated.

Considerable progress has been made in the study of the kinetics of the gasification reactions of brown-coal chars, and in particular in the study of the catalytic effects of the ash constituents of the coal on the water gas shift reaction. An investigation of the clinkering behaviour of the coal ash is also in progress.

Research into the production of a high calorific value gas has progressed to the

stage of design and partial construction of experimental equipment for operation at pressures of up to 50 atm.

An investigation of the carbonising behaviour of brown coal in a fluid bed is nearing completion.

ORGANIC CHEMISTRY

The work of this Section has been chiefly directed to the study of wool wax and sugar-cane wax, which are both potentially of economic importance; the study of the alkaloids of Australian flora, some that give rise to diseases in stock and others that might have useful therapeutic and other properties; a study of the mechanism of the phenolformaldehyde condensation; and the further investigation of products which can be obtained as the result of reaction between acetone and ammonia.

The study of wool wax, a by-product of the woollen industry, has been continued with the object of isolating the wool-wax alcohols and determining their structures.

Sugar-cane wax

Several thousand tons p.a. of sugar-cane wax are potentially available from the solvent extraction of the filter muds from cane-sugar mills. A refining and bleaching process, described in the previous report, involves removal of undesirable constituents by heating under reduced pressure and bleaching by chromic acid. It gives a hard, pale-yellow wax which is essentially a mixture of higher fatty acids. The cost of producing this bleached wax has been estimated as closely as is possible from laboratory data and it appears that it could be sold at a competitive price. In attempts to convert this wax into a series of ester waxes, much unexpected difficulty has been met. Although it is readily esterified with simple monohydric alcohols, only incomplete esterification has so far been effected with polyhydric alcohols, which should yield wax esters of greater value to the wax industry than sugar-cane wax.

PHYSICAL CHEMISTRY

Surface chemistry continues to be the chief subject of investigation in this Section, with particular reference to the flotation process by which mineral concentrates are separated from ores, and to the allied problems of detergency.

The efficiency of industrial condensers is partly limited by the transfer of heat across the thin stagnant layer of condensed water which forms on the cooling surface. If a water-repellent surface is formed on the condenser, the steam condenses as droplets instead of as a film. The resultant increase in the amount of the highly conducting metal surface of the condenser which is exposed to the vapour phase brings about a substantial improvement in the efficiency of the condenser. Recent work has been directed to the retention of the water-repellent film, which is at present the chief practical difficulty.

CEMENT AND CERAMICS

The programme of the Cement and Ceramics Section is made up largely of investigations of a long-term character, but testing work and other short-term projects are undertaken when the Section has special facilities not available elsewhere. Some new investigations have been begun, but are severely limited by the acute shortage of laboratory accommodation.

Cement-aggregate reaction

The work in the investigation of cement-aggregate reaction, which is concerned with deterioration produced in concrete by expansive reaction between the aggregate and certain constituents of the cement, is being extended into a number of different fields. The action of reactive aggregate particles in expanding concrete specimens is being studied in order to increase the precision with which the probable behaviour in practice of cements and aggregates can be evaluated. The action of superincumbent load on the expansion of mortar is also being investigated. This investigation has much significance in the study of the behaviour of massive structures affected by cement-aggregate reaction. Additional work has been done on the properties and treatment of pozzolanic materials that can be used for correcting cement-aggregate reaction.

From the cement-aggregate reaction problem has evolved an investigation of crack development in cement paste, mortar and concrete, since the incidence of cracks has important applications in studies on concrete durability, and an investigation of the classification and reactivity of various types of silica.

The radioactive tracer technique can be applied to the study of some of these problems. Initially it has been necessary to develop methods of handling and preparing specimens. Attention is now being given to studying the movement of radioactive sodium in cement pastes and mortars, and in reactions between silica and sodium hydroxide.

Surface-active agents

The use of surface-active agents in cement and concrete is being studied. Possible improvements in the durability of concrete brought about by the entrainment of minute bubbles of air are being investigated. The mechanism of entrainment of air in cement pastes is at present being studied. Air entrainment cannot be explained entirely as being due to changes in the properties of the liquid part of the system. Equipment is being made for studying the durability of mortar and concrete.

Mineralogy

Recently, work on phase equilibria of a number of different systems has been recommenced. The systems that are being investigated should give valuable information on the constitution and chemistry of cement clinkers, cement kiln refractories and various metallurgical slags, for example, basic slags from Bessemer and open-hearth furnaces.

Refractories

A critical study of Australian gas works' refractories has given information on the after-expansion contraction and other characteristics of these materials, possible methods for improving the performance of the refractories and the temperature distribution and fluctuation in an operating gas retort. An investigation of the behaviour of gas works' refractories in the presence of heavy steaming has been started. Study of the mechanical and chemical factors which influence the durability of cement kiln linings has continued and attention has also been directed to the fabrication of stabilised clinker bricks for use in such linings.

MINERALS UTILISATION

There are many deposits of minerals in Australia which, although of great potential significance because of their extent and high quality, have so far been developed industrially to only a very limited extent.

Monazite

Work on monazite has been continued, with the object of improving separation of the rare earth components and thorium. A cyclic fractional precipitation process has been devised which permits relatively pure cerium and lanthanum compounds to be separated from mixed hydroxides derived from monazite. In addition, a mixed nitrate product containing other rare earths, which is suitable for their separation by fractional crystallisation or ion exchange techniques, has been produced.

The rare earths have been separated from thorium by the chlorination of monazite at high temperatures. Under these conditions, thorium chloride volatilises and the dry molten chlorides of the rare earths which remain are free from all major contaminants, except calcium and magnesium. This work has now been completed. A study has been made of the chemistry of stable complex compounds of the rare earths and certain organic compounds. These complex derivatives are being used to separate a number of the rare earths by fractional crystallisation, fractional precipitation or ion exchange.

Work on the recovery of thorium from monazite has been continued and has necessitated a chemical study of a number of thorium derivatives.

Zircon

The abundance of zircon in the beach sands of southern Queensland and northern New South Wales and the ever-growing importance of zirconium, of which zircon is the chief ore, provide a strong incentive for research on this Australian mineral.

Special attention has been paid to the separation of the closely associated hafnium from the zirconium, and two new methods of effecting this separation have been developed. One of these processes is particularly applicable to the production of large quantities of hafnium-free zirconium and application has been made for a patent covering this process. At the same time small quantities of pure hafnium oxide are being isolated.

Uranium

The programme of work on the extraction of uranium from low-grade titaniferous ores from Radium Hill, S. Australia, has been intensified, and flow sheets, operating details and tests have been worked out for two alternative processes by which the uranium could be satisfactorily recovered. One of these processes involves acid treatment of the ore and selective solvent extraction of the resulting liquor, has been chosen because of the simplicity of the plant required and its relatively low operating costs. Considerable progress has been made with the laboratory investigation of this process and its development on a pilot scale has been commenced. This ore is a very complex one and, besides uranium, it yields several useful by-products.

ORE DRESSING

Of 21 ore-dressing investigations in hand but uncompleted, six are concerned with tin ores and three with wolfram. Electrostatic separation with or without magnetic separation has been applied to beach sands, tin concentrates, brown coal and other products.

Examinations of gravity concentration of tin from a large low-grade ore body in New South Wales have been made.

Investigations to determine the reasons for incomplete recovery of gold in a large Western Australian plant treating a low-grade ore have been carried out.

The mining industry's demand for the ore-dressing investigations that are being carried out in co-operation with the Kalgoorlie School of Mines continues. During the year much attention was given to gold ores, particularly dumps and complex ores involving various difficulties in their metallurgical treatment. There was also a marked demand for help with other metals, particularly lead and silver ores. Tests were undertaken, for instance, in connection with the concentration of a dump of lead-containing minerals. Requests were also received for assays of wolfram ores.

Flotation

In the Physical Chemistry Section a satisfactory method of concentrating topaz (used in ceramic ware) has been devised. This mineral is extremely sensitive to salts dissolved in the water used in the flotation process. Work has continued on the separation of the tungsten mineral, scheelite, from King Island ore. No economic method has yet been found, and much of the difficulty appears to be related to the nature of the froth produced in the flotation operation. The surfaces of frothed solutions are, therefore, being studied by means of a new surface viscometer, and high-speed photography is being used to study the collapse of the froth walls. The cells of a froth are formed from single bubbles. These collapse more readily than does an aggregate of bubbles and, being simpler, are more easily studied. However, no simple correlation has been found between the factors which alter the time of their collapse and the behaviour of frothing agents.

ATOMIC PHYSICS

The Organisation is co-operating with the Physics Department of the University of Melbourne in a programme of research on nuclear physics and cosmic rays under the direction of Prof. L. H. Martin. Co-operative investigations on cosmic rays are also being undertaken at the University of Tasmania under the direction of Prof. A. L. McAulay.

Tracer elements

The Tracer Elements Unit has continued to provide advice and assistance to Australian users of radioactive isotopes, which find applications in many fields of scientific research. However, shortages of laboratory accommodation and staff have restricted activities and made it necessary to defer several new investigations.

During the year 64 shipments of 11 different radio-isotopes, totalling 1,443 millicuries, including labelled compounds, have been received. The bulk of these have been obtained from the Atomic Energy Research Establishment at Harwell and the Radiochemical Centre at Amersham. However, one shipment was from a U.S. commercial firm, one from the U.S. Atomic Energy Commission and severeal were cyclotron-produced materials supplied free of charge by the Department of Terrestrial Magnetism of the Carnegie Institution, Washington.

Radio-chemical synthesis and processing

When isotopically-labelled compounds have not been readily available from overseas suppliers, consideration has been given to their synthesis by the Tracer Elements Unit. During the period under review, C^{14}-labelled methyl ethyl ketone has been made for the investigation of the Meerwein-Ponndorf reaction by the Department of Chemistry, University of Adelaide. Trial carboxylations of Grignard reagents have been completed, enabling the preparation of acids such as acetic acid and phenylacetic acid labelled in the carboxyl group. Preliminary work is also in progress on the labelling with C^{14} of glycerol, and *a*-ketoglutaric acid in two positions.

In addition, sources have been prepared on particular types of mountings, or in a particular chemical form, as required by various users.

Pilot and assay experiments

Pilot tracer experiments and assay measurements have been made with several C.S.I.R.O. Divisions and other organisations. These have included collaboration with the Irrigation Research Station, Griffith, using long-lived radio-sodium, Na^{22}, to follow the movement of salt in the soil, and with the Walter and Eliza Hall Institute of Research in the assay of C^{14}-glycine.

Discussions have also been held with several industrial firms in connection with tracer applications, and experiments are planned in collaboration with a firm of chemical manufacturers for tracer studies of yields in industrial chemical processes under different conditions of plant operation.

For assay work, primarily of C^{14}-containing samples, wet oxidation methods for the production of barium carbonate are being developed.

The continued strong demand for radioactive assay equipment has been met with the help of the Organisation's Central Experimental Workshops. Further batches of cylindrical and end-window types of lead castles of improved design are under construction, and a prototype castle with an annular recess for powder samples is under test.

Recent publications

Unloading inflammable liquids. Issued by the U.S. Manufacturing Chemists' Association, the revised Manual, sheet TC-4, entitled 'Unloading flammable liquids from tank cars,' brings up to date standards adopted in America in 1942. The manual contains information on the safe handling of inflammable materials and describes in detail safety precautions which should be observed by unloading personnel.

'Nimonic' alloys. A revised edition of Henry Wiggin & Co.'s general publication, giving detailed properties of these well-known high-temperature materials has appeared. Although *Nimonic* 80A was primarily designed for use at high temperatures for short times, data in the booklet show that this alloy is also suitable for use for long periods at these temperatures. The curves were all obtained on material as heat-treated for aircraft service. Investigations are at present in hand to develop the best possible long-time creep properties and the properties shown in the booklet should, therefore, be taken as an indication of the minimum properties which can be developed. Also included are short notes on *Nimonic* 95, the latest published addition to the series of creep-tested wrought alloys, together with general descriptions of *Nimonic DS* and *Nimonic DT*, which are modifications of *Nimonic D* introduced recently.

Plant and Equipment

Pressure controller

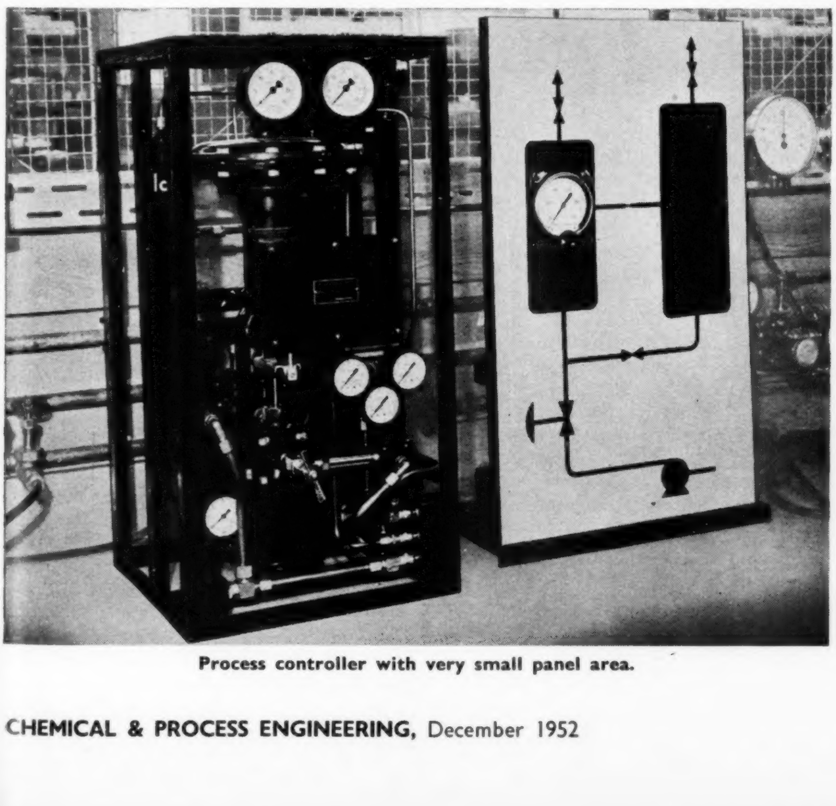
A new range of *Nullmatic* process control instruments which have a very small panel area and greatly reduced rear projection of the panel-mounted equipment is being marketed by Sunvic Controls Ltd. Further, the absence of pin joints, pivots, linkages and other moving parts is claimed to produce a control system requiring little or no maintenance and a controller having a lower 'noise' or spurious signal level than hitherto attainable. A typical process control system can be divided into two parts, *i.e.* the graphic panel found in modern control rooms and the pressure control mechanism in the actual plant.

The 'plant' section consists of two capacities in which air pressure is maintained by a compressor, the output of which is throttled by a diaphragm-operated control valve. On one of the capacities a pressure transmitter is mounted giving an output signal of 3 to 15 p.s.i. for the full range of pressure change within the capacity. The capacities are so connected by means of shut-off valves that they may be used to simulate a single- or double-resistance/capacity stage plant. A valve positioner is mounted on the control valve and filtered and regulated air supplies are provided for the positioner and transmitter.

The signal from the transmitter is passed to the control panel, on the face of which is a diagrammatic representation of the plant. A miniature panel control station, displaying the controlled pressure as received from the transmitter and the desired value as set up by the operator, is inserted in the diagram in a position equivalent to the measuring point on the plant. A control knob projecting from the station allows the operator to set up the desired value as required. In addition, the multi-point control station provides manual/auto changeover facilities for the *Nullmatic* controller which is mounted on a bracket at the rear of the panel. The output from this controller is taken to the valve positioner on the plant section, and thus controls the position of the diaphragm-operated valve. Three terms—proportional, integral and derivative—can be provided by the controller. A spring-loaded air switch on the control station enables the valve position to be shown as an alternative to the desired value.

A series of bleeds is provided on both capacities and these, with the interconnecting valve and restrictions, may be used to demonstrate the effect of single and multiple capacities and load changes on the plant characteristics. The adjustments for proportional band, integral time and derivative time are available on the controller, so that this can be adjusted to match the plant in each case.

A two-pen recorder is connected to the system, enabling the measured value and desired value to be recorded simultaneously on an enlarged scale, so that the behaviour of the plant and the control system under various conditions may be easily seen. The recorder pen is outside the control loop and its friction can have no effect on the performance of the controller.



Process controller with very small panel area.

New pasteurising unit

A pasteurising unit for liquids such as milk, heavy cream, syrup and oils heats a thin film of the product from both sides as it circulates through the apparatus. The unit, made by the Chicago Stainless Equipment Corpn., U.S.A., is claimed to be easily cleaned, simple to operate and flexible in its ability to handle a wide range of liquid food products. It can also be used as an evaporator or preheater. Available in a range of models, with processing capacities from 2,500 to 20,000 lb./hr., the unit can easily be connected to the piping and electrical lines of a food processing plant.

The heat-exchanger portion of the apparatus consists of a lightweight stainless-steel tube supported concentrically inside a larger stainless-steel tube. When the unit is in operation, a thin film of the liquid to be treated flows through the annular space between these two tubes, while steam circulates through the inner tube and around the outer tube, thus heating the product from both sides. Only a small volume of the product is in the unit at any one time. Operating pressures can be as high as 100 lb./sq.in. at gravity. Condensate can be discharged at pressures up to 25 lb./sq.in. at gravity and product outlet temperatures can be controlled to within $\pm$ 5°F.

Flue dust blower plant

To run boilers efficiently it is necessary to keep clean all parts of the equipment. Water surfaces should be free of scale. Flue dust should not be allowed to accumulate in furnace flues of Lancashire boilers, since it considerably reduces boiler efficiency. The flue gas temperature at the side dampers is usually 750°F. on clean boilers, compared with approximately 950°F. on boilers with dirty flues. Boiler efficiency thus drops considerably and a saving of approximately 6% can be achieved when the flues are kept clean.

Flue dust deposits, however, cannot be avoided, owing partly to inferior quality of fuel and partly to the methods of stoking. Automatic blower plants for Lancashire boilers are manufactured by Heat Economy Ltd. Their flue dust blower plant, especially designed for steam working pressures from 80 to 200 p.s.i., has now had several new improvements incorporated.

Some time ago the welded headers supplying steam to the different groups of soot blowers were replaced by rotary valves operated by a turret. This was an advancement, but a further improvement has now been effected by fitting the rotary valves with pulling motors combined with a time switch arranged so that groups of blowers can operate in sequence. By pressing the push-button starter a relay is activated and the time switch operated. The steam blowers in the furnace, bottom and side flues are then operated in the

proper sequence, steam being supplied to each group for approximately 2 to 3 min., according to the steam working pressure required and to the quantity of dust accumulated. The time switch is adjustable and it is only necessary to set once after the first tests. The soot blowers cannot be operated while the forced draught or the stokers are in operation.

Mechanical operation of the soot blowers is a great improvement, making the equipment completely foolproof and labour-saving and ensuring maximum efficiency. As blowing can be accurately timed, it is impossible to have dity flues due to short blowing time as sometimes happens with hand operation.

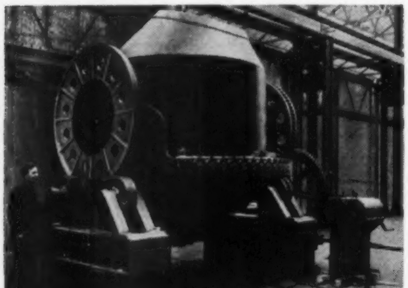
The soot blower equipment can be combined, when required, with a flue dust suction plant which can be either electrically driven or fitted with a steam jet ejector. The electric plant runs more cheaply, but the initial cost is slightly higher than the steam ejector.

Another improvement is the use of heat-resisting tubing made of a chromium alloy for all parts exposed to extreme heat inside the boiler flues. These tubes are capable of withstanding temperatures up to 1,000°C., and the burning away of the tubes, which formerly occurred, is now avoided. All parts inside the boilers are covered with a monolithic fireclay which reduces wear.

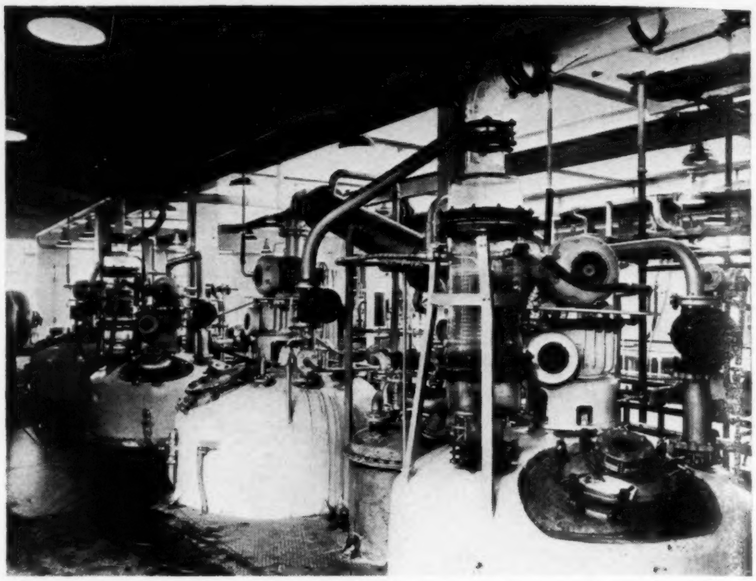
By the use of such plant the dirty, unsatisfactory and costly business of hand cleaning is eliminated and boilers can be kept continuously in commission, with a corresponding saving in coal. Further, boiler efficiency is maintained at a high level, since the flues are always clean. At the same time grit emission is avoided, as there are no flue dust accumulations and the gas velocities are not increased by restricted flues.

Copper-nickel converter

An interesting order recently completed and shipped by the Fraser & Chalmers Engineering Works of the General Electric Co. Ltd. is a copper converter for the Rustenburg Platinum Mines Ltd., South Africa. The converter is a duplicate of one forming part of a complete smelting plant supplied in 1937 for the smelting of



Vertical type copper-nickel converter for the Rustenburg platinum mines.



Glass-lined, stainless-steel vessels for the three acid hydrolysis stages in the manufacture of 'Chloromycetin' at the new London factory of Parke, Davis & Co. The new plant, which embodies many stainless-steel vessels, was supplied by the Balfour group of companies to Parke, Davis specifications.

copper-nickel concentrates and producing about 100 tons of copper-nickel in a 20-day campaign, working 20 hr./day. The plant is situated at an altitude of about 4,500 ft. above sea level in the Rustenburg area of the Transvaal. These converters, which are of the vertical type, are power operated by totally enclosed 15-h.p. motors running at 712 r.p.m. and designed for an a.c. supply of 500 V, three-phase, 50 c/s. The driving motor of the first machine was controlled by a drum-type controller provided with creeping or inching contacts. For the new converter a contactor control panel has been specially designed embodying two master control stations, to give local and remote control, and enables the converter to be traversed forward, reversed, inched forward and inched in reverse. For forward or reverse travel, the motor would normally run until the stop button is pressed or the circuit is tripped by a limit switch on an over-travel.

The travel of the converter is from the nearly vertical charging position to the pouring position slightly below horizontal, a total of some 105°, depending largely on the contents of the converter. The most important operation is that of pouring, which is performed slowly at about 5 ft./min. with the motor running at its lowest speed, as great care is necessary when slagging off to ensure that no metal is lost. The local control panel carries an emergency stop button and a control handle for starting and turning the converter; the remote control panel has a station selector and backing-out control for use when the limit switches have been tripped, also a control handle for inching the converter when pouring. There is, in addition, an emergency stop switch.

For further information on new plant and equipment please complete the coupon on page 684

A second control cabinet has been supplied to enable the original converter to be operated under the new system. All the electrical gear, which has been treated to withstand the fumes given off during the converting process, is enclosed in dust-proof cases.

Measurement of engine gas temperatures

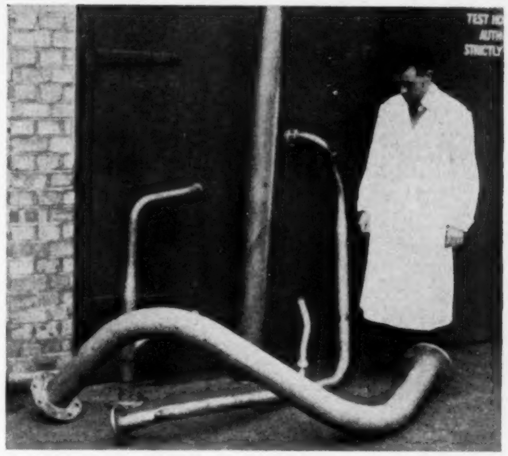
In the cylinders of high-speed thermal engines, where one cycle lasts only a few hundredths of a second, very rapid fluctuations take place in the temperature of the gas. The fluctuations are of great importance to the functioning of the engine, but are almost impossible to calculate. It has been found practicable to measure such rapid temperature fluctuations with the aid of an extremely fine metal wire connected as a resistance thermometer to an electric bridge. This wire, of a thickness of from 1.5 to 2 microns, responds to the variations in the temperature of the gas with a time-lag of only 1 to 1.5×10^{-4} sec. The fluctuations are recorded with the aid of an oscillograph; the oscillograms can be calibrated in a simple manner. The error in the measurement of the temperature is about 1°C., while the error in the phase angle is at most a few degrees. Measurements made by this method on an experimental single-cylinder air engine are described in *Philips Technical Review* (1951, **13**, (4), pp. 104-108).

Electrotinning Tubes and Awkwardly Shaped Apparatus

A METHOD of contact tin plating evolved during the war for speeding-up aircraft engine production is now being used for other industrial purposes such as the tinning of bores of fine tubes and the interiors of complicated apparatus. Large food and beverage handling equipment can now also be retinned, on site. Details of this new method are given in *Tin and its Uses* (1952, No. 26). The new development comprises two distinct processes. One is the use of aluminium for contact tinning to produce relatively thick deposits without the use of an external applied current; the other is the use of aluminium contacts during stannate tin-plating to boost deposition on awkwardly placed areas where otherwise the coating would be unduly thin.

During World War 2 it was found necessary to tin the inside of a copper centrifuge shaped somewhat like a horse-shoe, but the problem of designing a suitable internal anode seemed insoluble. After some experiments it was found possible to get a satisfactory internal coating from the standard sodium stannate plating bath by attaching pieces of aluminium strip to the copper shell at suitable points. The rate of deposition claimed was about 0.0002 in./hr. and the process of deposition continued after the initial complete covering had been achieved. In fact, the centrifuge in question withstood two years' intermittent flying service with varying coolants and suffered little deterioration.

Further experiments have established that if suitable light alloy contacts are employed during normal plating operations special internal anodes are unnecessary. As cases in point, a steel tube 8 in. long with a $\frac{1}{16}$-in. diam. hole was tinned inside and out in 20 min. with only a thin wire of light alloy placed in the bore; a tank 6-ft. long and 4-ft. diam. with several flanged inlets and outlets was successfully tinned by this dual process after efforts to electro-tin with internal anodes had left several bare patches in the inlet branches. Pipes 18-ft. long have been tinned by using a plait of wire as a contact. The pipes with their side branches were sealed to leave one end open. The wire was inserted and the pipes filled with hot solution from the tinplate bath and left overnight. Pipes tinned in this way have been in service circulating hot water or hot oil for nearly two years and are still completely coated.

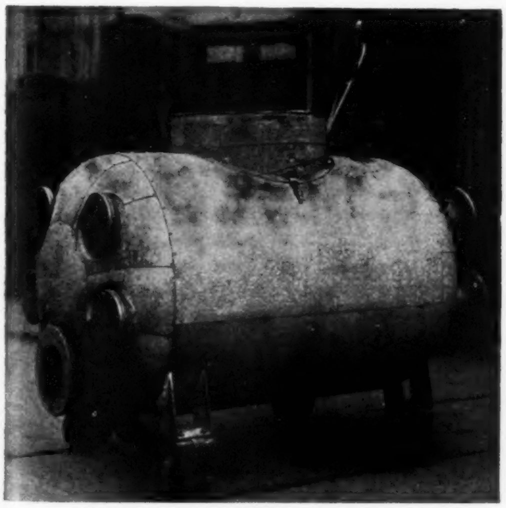


Examples of large pipes tinned internally by the use of a plait of aluminium wire instead of internal anodes.

This type of tin plating has also been used successfully on high-duty engine components to eliminate fretting corrosion, a coating thickness of 0.0005 to 0.001 in. being found best. Tin coatings produced by the contact process are said to be more dense than those produced by normal plating and the bond is so good that the process has been used for the tinning of bearing shells prior to casting on white metal.

The function of the aluminium contact is, of course, sacrificial. In the sodium stannate solution the aluminium is anodic and dissolves, releasing an equivalent amount of tin. The special feature of the process, however, is that the area of the aluminium must be small compared with the area to be plated (about one-fortieth is recommended). This gives rise to a relatively high current density on the aluminium and much of the tin deposited on its surface does not adhere and, in consequence, the plating continues steadily though slowly until the desired thickness of tin has been deposited. The sodium aluminate formed in the bath hydrolyses and an aluminium compound is precipitated on to the bottom of the bath together with some tin. In consequence, the valuable plating solution is not contaminated and no tin is wasted. The considerable amount of tin deposited loosely on the aluminium can also be recovered.

The concentration of sodium stannate can with advantage be reduced if the process is operated as simple displacement tinning without the use of an external plating current, an optimum concentration being around 50 g./litre. Where an external current is used the standard sodium stannate bath recommended by the Tin Research Institute is satisfactory.



A large vessel with complicated branches tinned internally by using suitable aluminium contact strips.

(Both photographs by courtesy of D. Napier & Son, Ltd.

Nickel-lining pipes by a new process

Owing to the shortage of nickel, American industries unable to obtain pure nickel tubing are turning to nickel-lined pipe. Nickel-lined steel piping is not new, but previously it has only been available in short lengths. Now a new machine has been developed by the Bart Manufacturing Corp. which, according to *Chemical Week* (1952, **70**, (22), 40), can line lengths of piping up to 20 to 21 ft. with diameters from $1\frac{1}{2}$ to 24 in. Steel pipe is cleaned and placed in the machine, pipe ends capped and an anode inserted. A nickel solution consisting of a mixture of inorganic nickel salts with a definite acid *p*H is then continuously pumped through the pipe, which is rotated during the process in order to give an even coating. The nickel can be deposited to any desired thickness, but for most purposes a coating in the range of 0.010 in. is used. Pipes coated with 0.007 to 0.010 in. of nickel are competitive with stainless steel. In addition to plating the inside of pipes, this process can also plate the outside, but inside coating only is more usual.

The principle economic disadvantages of this process is that it is only available in seamless steel pipe and weld fittings and, because of the normally thin coating, it can only be used where the corrosion rate is small and uniform. The cost is also high. Plating pipe costs up to three times as much as the pipe itself. However, in the chemical industry these pipes have important applications where protection of alkaline materials is required. It is used, for example, to handle hot caustic, hot fatty acids and organic chloride. Some kraft paper plants are also using them.

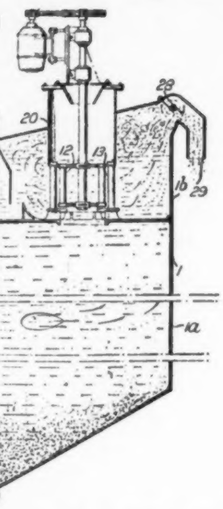
Chemical Engineering Invention

MONTHLY SUMMARY OF PATENT CLAIMS

Unit for recovering waste lubricants

A unit for continuously recovering contaminants from lubricating coolants comprises a vessel 1, Fig. 1, with a section 1*a* receiving the coolant and collecting relatively heavy particles of contaminant, the coolant flowing from this section to a flotation section 1*b* containing means for

FIG. 1



agitating and aerating the coolant to form a froth which is discharged together with lighter particles through an outlet 29, while the purified coolant passes to a receptacle 33. The froth is formed by a rotary motor-driven device 12 which aerates the liquid with air drawn through a casing 20. The froth is removed by a rotary skimmer 28. A byepass pipe 38, a control valve 36, and a check valve 39 are provided to maintain a substantially steady flow of liquid through the clarifier, part of the clarified liquid being re-circulated if the flow of incoming liquid falls below the desired rate.

In a modification shown in Figs. 2 and 3, the clarifier comprises three sections 41, 42, 43. The coolant enters the section 41 from which settled solids are removed by rakes 47 on endless chains 48 and delivered to a portable tank 60. The coolant flows from the section 41 by way of a slot 59, a baffle 61 and an opening 62 into section 42 which is provided with a rotary froth-flotation device 65. The froth is removed by a skimmer 68 and the clear liquid flows through an opening 76 into the section 43 from which it is pumped through pipe 78. In a further modification three cylindrical members are arranged co-axially, the heavier solids being collected in the outer chamber, the froth in the inner chamber, and clarified liquid in the intermediate chamber. In the construction shown in Fig. 8 the froth is formed by a blower supplying compressed air through a distributor 155 provided with a canvas sheet 157. The distributor divides a casing 150 into two sections, the lower section collecting heavier solids 152 from coolant supplied through pipe 151, and the upper section containing the froth which is removed by a skimmer 158. Clear liquid flows through outlet 162. Means may be provided, as shown in Fig. 10, for removing automatically the solids in the settling chamber 200. The chamber has a conical base with an opening fitted with a plug 202 which is connected to a float 207. When sufficient solids accumulate in the chamber the float 206 rises and through

FIG. 8.

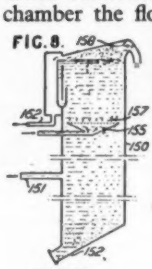


FIG. 2.

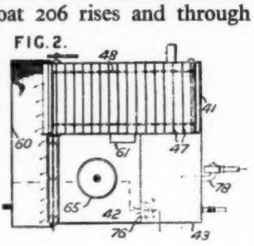


FIG. 10.

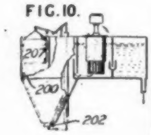
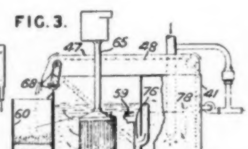


FIG. 3.



lever mechanism withdraws the plug 202 from its seating allowing the solids to escape. Specification 615,705 is referred to.—619,214, *American Cyanamid Co.*

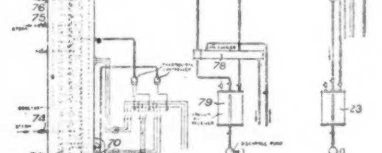
Dehydrator for fatty oils

Glyceride oils of the drying and semi-drying types are heat-bodied by subjecting a confined stream of the oil flowing upward in a reactor column to a bodying temperature while agitating the stream to maintain it substantially uniform in cross-sectional composition, and while continuously removing volatile contaminants from the oil. Oils which may be thus treated include linseed, chinawood, perilla, cottonseed, corn, soya bean and sunflower oils and fish oils such as sardine and menhaden oils. Dehydrated castor oil may also be treated in this way. The saturated fatty compounds of relatively low molecular weight remaining in the oil after the heat-bodying reaction may be selectively hydrolysed with steam and converted to their corresponding fatty acids which may then be vaporised at a relatively low temperature together with other volatile non-drying fatty contaminants and removed from the oil by vacuum or steam distillation.

The oil may be heated to the bodying temperature before introduction into the reactor and, if desired, at least in part by heat exchange with the hot treated oil leaving the reactor. The oil may be maintained in the reactor under a non-oxidising atmosphere, if desired at a relatively high vacuum. However, it may be preferred to body the oil while mixed with a solvent or dispersing medium for the polymerised oil, for example, petroleum, coal tar derivatives and turpentine, and in this case an elevated pressure may have to be maintained in the reactor. Ester gum or resin, particularly oil-soluble phenol-aldehyde or urea-aldehyde resin, may also be used as the dispersing medium and may be incorporated with the oil prior to the heat-bodying or before or during the removal by distillation of the non-drying contaminants from the oil. In the case of phenol-aldehyde and urea-aldehyde resins incorporated before the heat-bodying, reaction takes place between these resins and the oil to form high molecular weight compounds. If desired, catalysing or reacting media such as determined amounts of oxygen or atmospheric air, sulphur, or chlorine vapours may be incorporated with the flowing stream of oil, to accelerate the bodying reaction or by reacting with the oil to effect a desired isomeric or other change in the composition of the oil.

Apparatus for carrying out the heat-bodying treatment may comprise a preheater arranged to heat a confined flowing stream of the oil to bodying temperature, a reactor column communicating adjacent its lower end with the preheater, pressure-creating means arranged to force oil through the preheater and in an upwardly flowing stream through the reactor column, heating and cooling means associated with the reactor column and arranged to maintain the stream of oil in the reactor column at a substantially constant bodying temperature, vacuum-creating means associated

FIG. 3.



with the reactor column and effective on the stream of oil therein, and agitating mechanisms in the reactor column arranged so that the flowing oil stream is agitated horizontally, thereby maintaining it substantially uniform in cross-sectional composition.

In Fig. 3, oil is supplied to inlet 66 of reactor 65. Electric induction heating coil

(*Concluded on page* 683)

World News

GREAT BRITAIN

I.C.I. to make titanium

Imperial Chemical Industries Ltd., who have been carrying out a three-year research and development programme on the manufacture of titanium, have decided that this work has reached a stage where they can immediately start to erect pilot plants for the production of wrought titanium and its alloys. When these plants are in production they will provide a British source of supply for the development of prototype applications in the engineering and aero engineering fields.

Balfour director's tour

Mr. I. M. O. Hutchison, Sales Director of the Balfour Group of Companies, gas and chemical engineers, recently returned from an eight-week business tour of South Africa.

He travelled widely, visiting Johannesburg, Durban, Port Elizabeth, Cape Town, Lourenco Marques and Nairobi. On his return he reported that the prospects in these territories for the Group's many engineering products were encouraging, and steps are already being taken to appoint agents in South Africa.

Trade in ferro-alloys

The Minister of Supply has restored the right of individual manufacturers and merchants to import and distribute all ferro-alloys without exception.

For some years past licences for the import of certain important types of ferro-alloys have been granted only to the Central Buying Organisation of the British Iron and Steel Federation (B.I.S.C. Ltd.) which, under arrangements agreed with the Ministry of Supply, has bought in bulk and acted as distributor to all users in the U.K. As a result of the Minister's decision, licences to import all such ferro-alloys will, as from January 1, 1953, be issued to individual firms as well as to B.I.S.C. Ltd. This relaxation of control has been made possible by the improvement in supplies.

The alloy metals affected are: Ferro-silicon, ferro-chrome, ferro-silico-chrome, silico-manganese, silico-spiegel, ferro-phosphorous, and calcium silicide.

Applications for import licences should be addressed to the Board of Trade.

This latest decision follows the removal by the Ministry of Supply in recent months of a number of other controls affecting metals. These include:

(*a*) The removal of price control of re-melted and scraplead, secondary zinc alloys, zinc scrap, gun metal scrap and blast furnace ferro-manganese;

(*b*) The removal of limitations upon the use of zinc and alloy steel containing nickel and molybdenum; and

(*c*) The removal of restrictions upon the acquisition of all forms of lead, re-melted zinc, zinc alloys, copper scrap and residues and copper alloy scrap and residues.

Metal powder agency

J. and J. Makin (Metals) Ltd. have appointed The British Metal Corporation, London, E.C.2, sole selling agents throughout the world, excepting Great Britain and Australia. This agency covers all Makin's products, i.e. electrolytic copper powder; atomised copper, tin, brass and bronze powder, etc.

Furnace company expands

Building work has now begun on a site adjoining the Birlec main offices and works at Tyburn Road, Erdington, Birmingham. These extensions will provide additional Drawing Office capacity and other facilities, while similar work at the other end of the factory will lengthen the existing works bays. These developments will enable the company to provide better service to its many customers and also help it to keep pace with its increasing volume of business.

This constructional work is part of a larger project, the complete realisation of which is, however, delayed by current building restrictions.

New plants for antibiotics

The building of new extensions costing £750,000 is proceeding at the Speke premises of The Distillers Company (Biochemicals) Limited. These extensions will greatly increase the fermentation capacity of this already important manufacturer of penicillin, streptomycin and other therapeutic substances obtained from fermentation processes.

WEST GERMANY

New synthetic rubber

The Association of the West German rubber industry has said that production would soon be switched to the manufacture of new types. Instead of Buna S3, a slightly coloured type would be manufactured, and Buna SS would also be produced as a slightly coloured type. It was further planned to begin production of oil-plasticised rubber; new latex varieties would also be produced in connection with the new types.

Testing the new materials and converting the production installations at the Chemische Werke Huels plant, the sole German producer of Buna at present, would only require a brief interruption of production.

Conversion of production was to be carried out in close co-operation between the Huels plant and the rubber processing industry. It would be used as basis for a more extensive production later.

EAST GERMANY

New potash fertilisers

The Soviet Zone of Germany is at present exporting greater quantities of potash than the whole of pre-war Germany, and further increases in potash production by 1955 are planned under the present five-year plan, according to VWD, the West German news agency. Production capacity in East Germany now stands at approximately 1.5 million tons of K_2O annually and two thirds of Germany's potash reserves are in the Soviet Zone.

Present production in East Germany embraces all of the well-known fertiliser salts, with the emphasis on 40% potassic salt (38-42% K_2O), which users in Germany and neighbouring countries prefer.

Meanwhile, new potassic salts with magnesium content have been developed. From these, four types of fertilisers are being made that can be used for the individual needs of different crops.

The first of these is **Mg potash** (Emgekali) with 33-37% K_2O, at least 15% $MgSO_4$ and up to 0.2% B_2O_3. Mg potash is used for fodder and sugar beet, vegetables such as cabbage, stone and core fruits, feed grasses and for tropical and sub-tropical crops (especially coffee, cotton and oilpalms, etc.).

Reform potash (Reformkali) is another of the magnesium phosphate fertilisers. It is composed of 26% K_2O, 26% $MgSO_4$ and a maximum chlorine content of 12.5%. Reform potash is suitable for all crops that are sensitive to chlorine such as potatoes, berry fruits and tobacco. It may also be used for citrus and for crops in soil containing sodium oxide.

The other two fertilisers containing magnesium are **magnesia kainite** (12-15% K_2O and at least 15% $MgSO_4$) and **magnesia sylvinite-kainite** (16-20% K_2O and at least 15% $MgSO_4$). They are both suitable for all crops in light sandy or loamy soil with low mineral content.

With potash in great demand in Europe and overseas, the port of Wismar has been developed to cope with increased shipments. The harbour and the approaches to it have already been deepened to admit ships of 7,000 tons and are to be deepened further to allow ships of up to 10,000 tons (mainly for the Far East) to load potash cargoes there.

NORWAY

New finance for Norsk Hydro

Norsk Hydro is to accept a bank loan of £3,750,000 to finance a large-scale increase in production. The company's manufacture of nitrogenous products at Heröya, Rjukan, Notodden, and Glomfjord is to be increased by means of a new electrolytic process, and the production of complete fertiliser, urea, and magnesium is also to be increased. New factories are to be built for producing carbide and phosphor.

SWEDEN

Five-year chemical plan

The Swedish Association of Chemical Industries has studied present development trends and outlined a 5-year expansion programme in a report to the Department of Finance.

Increased production was recommended for most plants only if the output can be based on domestic raw materials. New facilities for the manufacture of methanol, phenol, formaldehyde, pharmaceutical products, plastics, and synthetic fibres were listed as especially desirable.

The success of the proposed programme, the association stated, depends upon the Government's attitude on investment taxes, import duties, and building permits. The Association considered that the chemical industry has not received the building permits it required and that allotments made on the basis of its development years ago should no longer apply.

Permits were granted in 1951 for buildings costing only $1 million; applications for construction valued at $15 million have been made in 1952. However, many applications are for warehouses, steam plants, personnel quarters, and similar buildings rather than for new production facilities. Applications for permits in the category of new facilities have totalled $4,400,000 so far in 1952, including $1,300,000 for the ammonia and calcium-nitrate plant at Kvarntorp.

FRANCE

Exploitation of low-grade ores

A working party of European and American specialists, meeting in Paris at the headquarters of the Organisation for European Economic Co-operation, has completed a two-day study of methods which might lead to the exploitation of metallic or non-metallic low-grade minerals, that is those that are marginal or whose complex nature makes them difficult to treat. This study is complementary to research already being undertaken on the conservation and substitution of scarce raw materials.

An exchange of information took place on the available resources in equipment and scientific personnel at the disposal of those European research laboratories which are likely to study this particular sector, and on the research at present in progress.

The information collected—which will be completed by supplementary data to be supplied by the representatives of the various countries who attended the meeting—will be assembled in a draft report for submission in due course to the Productivity and Applied Research Committee of O.E.E.C.

In the meantime, the experts unanimously agreed on the importance of certain basic research, as a greater knowledge of the chemical and physical processes involved in what is now regarded as the science of mineral dressing would, in due course, allow certain types of ores to be employed which are at present considered unusable. With a view to encouraging further research on certain particular subjects which the experts consider it would be most profitable to study, they have drawn up the following list of studies. They intend, in their report, to draw the attention of the Productivity and Applied Research Committee and of European scientific and technical circles to this list:

1. Mechanics of grinding.
2. Classification of very fine sizes.
3. Dense medium separation of fine sizes, *i.e.* smaller than 10 mesh or 1.5 mm.
4. Flotation of oxides such as eassiterite, chromite, hematite and magnetite, and pitchblende.
5. Flotation of oxidised or weathered ores such as those of lead and zinc, copper, and nickel.
6. Influence of soluble salts in flotation.
7. The beneficiation of slime by method of selective coagulation.
8. Electrostatic separation having in view conditioning before separation.
9. Pelletising.

AUSTRALIA

Glass fibre plant

Australian Consolidated Industries Ltd. plans to manufacture glass fibres in Australia in the near future, the company's chairman has stated at the annual meeting in Melbourne. He said several Australian firms were now experimenting on the application of glass fibres, with polyester resins, to the making of glass-resin laminates which were already used extensively in America. The locally-made material would have wide use in the insulation field.

CANADA

Liquid sulphur dioxide plant

Canadian Industries Ltd. has put into operation at Copper Cliff, Ontario, what it describes as Canada's first plant for manufacture of liquid sulphur dioxide, used as a bleaching agent and preservative. The plant will have an annual output of 90,000 tons, equal to the total production of liquid sulphur dioxide in the rest of the free world and the equivalent of 45,000 tons of elemental sulphur.

PAKISTAN

New starch factory

Work has begun on the construction of a new starch factory for the Zeb Corn Products Co. at Peshawar. The plant is expected to cost 1 million rupees and will have an output of about 10 tons/day of starch. In addition it will produce dextrines, glucose, oilcake and gums.

Production is expected to be sufficient to cover the country's needs and to allow a margin for export—probably to the Middle East, Singapore and Burma. Machinery for the new plant has already been imported from Germany.

INDIA

More aluminium to be made

India, at present producing around 4,000 tons of aluminium p.a., is planning to increase capacity to 20,000 tons p.a. One of the two leading aluminium concerns, Indian Aluminium Ltd., now operating the Asansol (West Bengal) plant, has applied to the Government for permission to erect a plant of 15,000 tons' installed capacity at Hirakud (Bihar State). The estimated cost of the project is some £5,250,000.

Indications are that the Government is willing to accede to the request. The planning commission has appreciated the need for increasing India's aluminium output and has suggested an installed capacity in the country of 20,000 tons. Indian Aluminium and the Aluminium Corporation of India, the latter runs the Alwaye (Travancore-Cochin State) plant, have a combined installed capacity of 5,000 tons p.a.

Raw materials present no difficulties in the success of the plan. India is rich in bauxite deposits, mostly in Bihar and Travancore-Cochin State. Power supplies, however, need to be stepped up before the plan can materialise. At present there is insufficient power to operate the current plants at their full capacity.

The success of the plan would mean that India, at present an aluminium importer to the extent of nearly 10,000 tons p.a., would be self-sufficient in this metal.

TiO_2 factory closed down

India's only titanium factory has been closed down temporarily because of high production costs. The factory is at Trivandrum, the capital of Travancore-Cochin State, and the Government of the State holds 51% of the shares.

It is thought likely that the Government of the States will make representations to the Federal Government to see that the concern is not wound up.

CEYLON

Beach mineral sand project

Ceylon is expected to commence small shipments of refined monazite sand to overseas markets before the end of the year. A few tons of this material, which has a radioactive mineral content, have been produced by a pilot plant imported for the purpose. The scheme has been sponsored by the Government and world tenders have been invited for the supply of beach sand dressing plant to allow commercial production to go ahead. A new factory with a capacity of handling 125,000 tons p.a. of raw sand is planned to be erected in the Trincomalee region.

Industrial schemes reviewed

Following the Report by the World Bank Mission and in view of the serious financial position with which the country is faced, the Cabinet have reviewed the various industrial projects planned. These

are the establishment of factories for the manufacture of iron and steel, DDT, caustic soda and chlorine, textiles, paper, glass, acetic acid and the arrangements for the purchase of fishing and research vessels. The Ministry of Industries are to submit a statement showing the amounts required for vital expenditure for each scheme during the quarter ending December 31. As a result it is not unlikely that the iron and steel project will be suspended and there may be some delay in placing the contract for the textile mill, if it is decided to proceed with this project.

NEW ZEALAND

Pulp and paper project

The Prime Minister, Mr. Holland, has stated in the House of Representatives that the Murupara pulp and paper project is likely to become New Zealand's fourth great industry following the dairying, meat and wool industries. In moving the second reading of the finance bill which authorises the Government to subscribe for shares and make advances to industry, he said the scheme was expected to be operating within three years.

The project would exploit Kaingarao—the largest man-made forest in the world—and would require about £15 million capital. Of this sum £7 million or less would be required from overseas. To meet the cost of works it was intended to raise £4,400,000 in New Zealand, £3,300,000 in the U.K., £300,000 in Australia, £900,000 in Canada, £1,800,000 in the U.S. and £300,000 in Sweden and Switzerland.

Mr. Holland said world-wide tenders were now being called for equipment and it appeared the majority of orders would go to the United Kingdom.

MEXICO

U.S. firm to build sulphur plant

The Pan-American Sulphur Co. is to build a $5 million plant to process sulphur at Jaltipan, in southern Vera Cruz, on the isthmus of Tehuantepec, in Mexico. The plant will be located on concessions totalling 22,000 acres around the Jaltipan salt dome and will be capable of producing between 300,000 and 600,000 long tons annually. The plant will use the Frasch process and be the first of its type outside the U.S., according to Mr. J. R. Parten, Pan-American president.

To finance the operation, Pan-American has obtained an eight-year $3,664,000 loan from the U.S. Export-Import Bank and plans a $3 million offering of common stock.

Construction of the new sulphur plant is expected to begin next February and should be completed by August 1954, Mr. Parten estimated. While only about 40% of the Jaltipan dome has been explored for sulphur, its reserves have already been appraised as sufficient to justify a plant, said Mr. Parten.

At present, Pan-American is not producing sulphur commercially, but has spent over $1 million in exploration of the Jaltipan dome, through a subsidiary, Gulf Sulphur Co. de Mexico S.A. Exploration began late in 1947 and to date 80 bore holes have been drilled. With its estimated annual production capacity of 300,000 to 600,000 long tons, the Pan-American plant would compare in size with Texas Gulf Sulphur Co.'s new plant at the Spindletop dome in Texas and Freeport Sulphur Co.'s new Garden Island development in the swamps of South Louisiana, it is stated. The Jaltipan plant, however, would be considerably smaller than such giant plants as the one operated by Texas Gulf at Newgulf, Texas, producing well over 1,500,000 tons a year.

UNITED STATES

New synthetic rubber

Considerably more abrasion resistance is claimed for a new type of GR-S synthetic rubber, now in the pilot plant stage, by its manufacturers, the Naugatuck Chemical Division of the U.S. Rubber Co.

Dr. L. H. Howland, director, of synthetic rubber research and development for the company, read a report, the first public announcement of the process, before the Rubber Division of the American Chemical Society. Laboratory tests, Dr. Howland said, show that the new synthetic gives 30 to 50% more abrasion resistance than standard 'cold' rubber. It also has good resistance to heat, cracking caused by rapid flexing and the deteriorating effects of ageing in air.

The new rubber is made possible by the addition of rosin chemicals, by-products of turpentine manufacture to an extra tough 'cold' type of GR-S synthetic rubber. The rosin chemicals make the rubber easier to fabricate into products and improve its end product qualities, Dr. Howland said. The chemicals are added to the rubber when it is in the latex or liquid form. Carbon black may be added at the same time.

New device for eliminating industrial smoke

A new device for the smokeless burning of petroleum fumes has been demonstrated at Linden, New Jersey, by the Esso Standard Oil Co. A safety flare is used to reduce pressure on refinery equipment during interruptions in production. In an operating emergency the fumes, instead of building up pressure in equipment, are pushed out through the safety flare where the highly-inflammable gases are burnt. This new type of safety flare permits the introduction of gas and water spray, and its combustion and final flaring in gradual stages.

The device consists of three concentric masonry stacks, the largest of which is 30 ft. high and 14 ft. in diameter. Gas and water are combined in the small innermost stack. As they emerge, two pilot lights ignite the mixture for initial combustion in the second stack. The third and outer stack affords a larger and better draft for the final flaring of the mixture, thus confining the entire operation within the safety flare itself.

Biggest de-asphalter to be built

The Humble Oil and Refining Co. has awarded The M. W. Kellog Co. the contract for the design and construction of a unique solvent de-asphalting plant at Humble's Baytown (Texas) refinery. Said to have twice the capacity of any de-asphalter so far, the plant will charge 28,000 barrels/day of vacuum reduced crude, providing additional clean feed stock for two recently enlarged fluid catalytic crackers at Baytown.

The erection of the de-asphalter will start as soon as materials are obtained.

Ammonia urea plant

Grace Chemicals Co., recently-formed wholly-owned subsidiary of W. R. Grace & Co., is to build an ammonia urea plant, its first manufacturing unit in the Woodstock area, six miles from Memphis, Tennessee. The plant will cost approximately $18 million and will produce nitrogen in the form of ammonia and urea for both agricultural and industrial uses. The plant will be 'on stream' in the summer of 1954.

Company officials state that the plant is only the beginning of the company's activities in the petro-chemical field. Plans are under way for the integration of other petro-chemical manufacturing operations into the new plant.

Patents

(*Concluded from page* 680)

70 supplies heat to the lower part of the reactor and the oil is agitated by the agitating means 69. The oil while passing slowly through reactor 65, preferably is mixed with steam supplied through inlet 74. The steam so supplied preferably is sufficient only to effect vaporisation of volatile contaminants, additional steam being supplied through inlets 75 and 76 if it is desired to hydrolyse the non-drying glycerides. Fatty acids with other contaminants vaporise and pass from the oil together with steam through outlet 21. They are condensed in condenser 22 and collected in receiver 23. The treated oil passes from reactor 65 by outlet 77 to cooler 78 and is collected in receiver 79. Apparatus is also shown in which castor oil is continuously dehydrated and the dehydrated castor oil is then continuously bodied. The dehydration reaction may be carried out in the presence of catalysts such as non-oxidising acids, particularly sulphuric, hydrochloric or acetic acid, strong alkalis, heavy metal salts, and metal oxides, particularly aluminium or zinc oxide. The catalyst is preferably mixed with a suitable porous bulking or distributing medium, such as fuller's or diatomaceous earth, before addition to the oil.—617,151, *R. A. Carleton.*

MEETINGS

Institution of Chemical Engineers

December 9. 'The Use of Sulphuric Acid in a Totally Enclosed System,' by J. L. Edgar, 5.30 p.m., Geological Society, Burlington House, London, W.1.

December 13. 'Recent Developments in the Technique of Making Fused Caustic Soda,' by G. J. Lewis, 2.30 p.m., Stork Hotel, Liverpool. Joint meeting with the S.C.I.

GRADUATES' AND STUDENTS' SECTION

December 12. 'The Production of Chlorine,' by C. R. Black, 6.30 p.m., Caxton Hall, Westminster, S.W.1.

Chemical Society

December 11. 'Chemical Research at Harwell,' by R. Spence, 7.30 p.m., University College, Hull. Joint meeting with the R.I.C. and the University College Scientific Society.

Society of Chemical Industry

December 10. 'Synthetic Detergents in Commercial and Domestic Use,' by G. R. Perdue, 6.30 p.m., Mason Theatre, The University, Edmund Street, Birmingham 3.

December 11. 'Adventures in Synthetic Fibres,' by Dr. Traill, 7.30 p.m., North British Station Hotel, Edinburgh.

December 16. 'Instrumentation in Analytical Chemistry,' by A. B. Crawford, 7.30 p.m., Lea Park Rooms, Falkirk.

AGRICULTURE GROUP

December 15. 'Chemical Control of Animal Parasites,' by H. E. Harbour, 5.30 p.m., Burlington House, Piccadilly, London, W.1.

CORROSION GROUP

December 8. 'The Corrosion Resistance of Stainless Steel,' by Dr. U. R. Evans, 6.45 p.m., Grand Hotel, Leopold Street, Sheffield.

FINE CHEMICALS GROUP

December 12. 'Ion Exchange and its Applications in the Fine Chemical Industry,' by E. L. Streatfield, 7 p.m., Chemistry Lecture Theatre, King's College, Strand, W.C.2.

PLASTICS AND POLYMER GROUP

December 9. Bulk polymerisation: 'Styrene,' by M. F. Vaughan; and 'Methyl Methacrylate,' by H. Jones; 6.30 p.m., Burlington House, Piccadilly, London, W.1.

January 2. 'Textile Fibres—Variations on Some Familiar Themes,' by J. R. Whinfield, 6.30 p.m., Textile Institute, 10 Black Friars Street, Manchester.

Royal Institute of Chemistry

December 11. 'Some Recent Developments in Physical Methods of Chemical Analysis,' by A. C. Menzies, 7.30 p.m., Acton Technical College, High Street, W.3.

Liverpool Metallurgical Society

December 11. 'Friction and Lubrication,' by D. Tabor, 6.30 p.m., Liverpool Engineering Society, The Temple, Dale Street, Liverpool.

Institute of Metals

December 12. 'The Mechanism of Adhesion of Electro-Deposits upon Aluminium,' by G. L. J. Bailey, 6.30 p.m., The University, St. George's Square, Sheffield. Joint meeting with the Institute of Metal Finishing.

January 6. 'Recent Advances in Alloy Chemistry,' by Dr. J. W. Christian, 7 p.m., Black Hall, St. Giles, Oxford.

North-East Metallurgical Society

December 16. 'Recent Advances in Copper and Copper Alloys,' by E. Voce, 7.15 p.m., William Newton School, Norton, Co. Durham.

Institute of Metal Finishing

December 15. 'Some Aspects of Barrel Plating,' by A. W. Wallbank, 6 p.m., Northampton Polytechnic, St. John Street, London, E.C.1.

Institute of Petroleum

December 10. 'Liquefied Petroleum Gases: A Symposium.' 'Production,' by E. Square; 'Distribution,' by S. Shaw; and 'Applications,' by T. H. Taylor; 5.30 p.m., 26 Portland Place, London, W.1.

Institute of Refrigeration

December 16. 'Factors Governing the Design of Chambers for Very Low Temperatures, including those Operating under Cyclical Temperature Conditions,' by S. H. W. Richards, 5.30 p.m., the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1.

Institution of Works Managers

December 9. 'Industrial Finishing,' by M. S. Goose, 7 p.m., Grand Hotel, Birmingham.

Physical Society

December 8. 'Methods of Measurement of Elasticity of Solids,' by G. Bradfield, 5 p.m., Science Museum, London.

Hull Chemical and Engineering Society

December 16. 'Some Aspects of Industrial Toxicology,' by E. E. Connolly, 7.30 p.m., Church Institute, Kingston-upon-Hull.

The Institute of Fuel

December 17. 'Removal of Sulphur Oxides from Flue Gases,' by R. Llewellyn Rees; 'Recovery of Sulphur from Flue Gas by the Use of Ammonia,' by Dr. S. R. Craxford, A. Poll and Dr. W. J. S. Walker; and 'Survey of the Concentration of Sulphur Dioxide in the Air of South-West London—A First Appraisal of Results,' by S. H. Richards, 6 p.m., Royal Society of Arts, John Adam Street, London, W.C.2.

Hull Association of Engineers

December 12. 'Industrial Application of Atomic Energy and its Products,' by Denis Taylor, 7.30 p.m., Kingston-upon-Hull.

Chemical & Process Engineering

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AUTHOR INDEX

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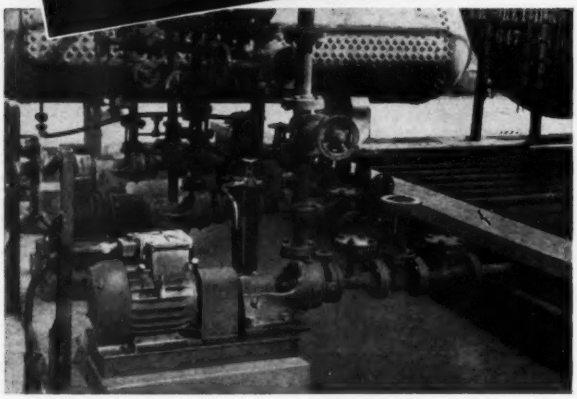

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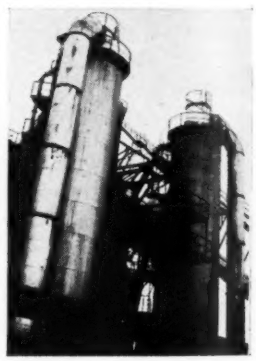

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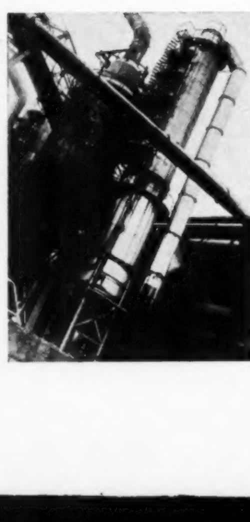

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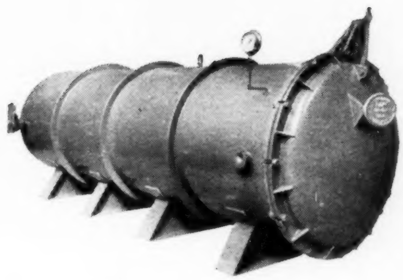

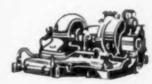

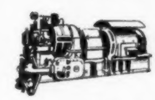

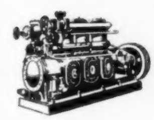

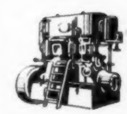

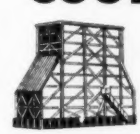

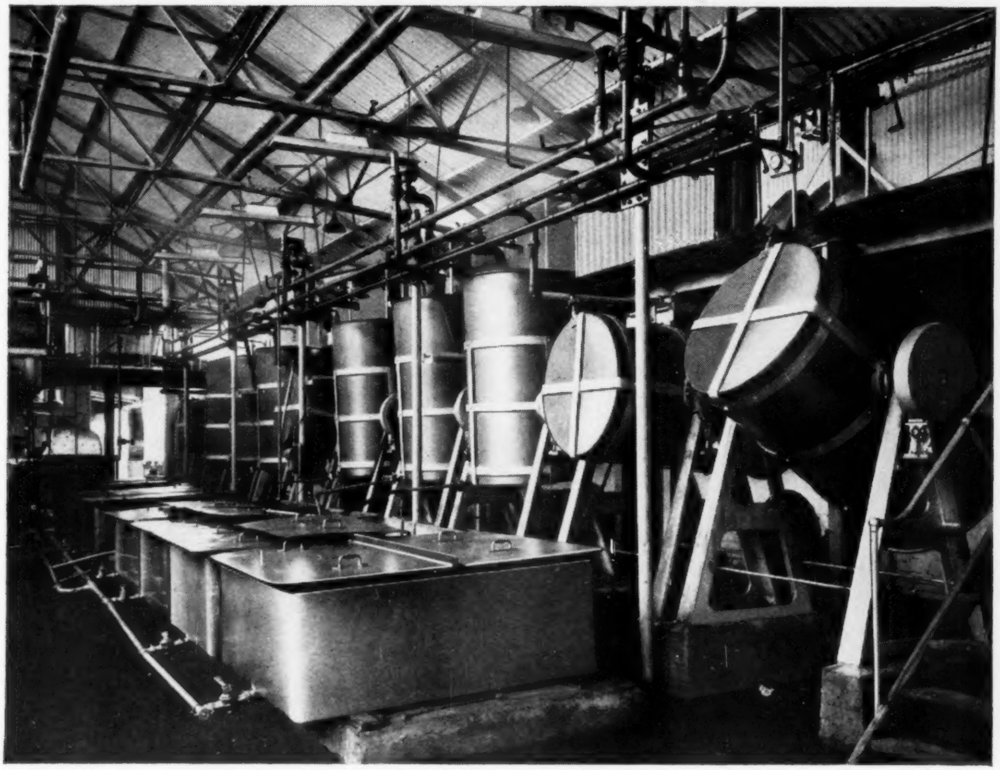

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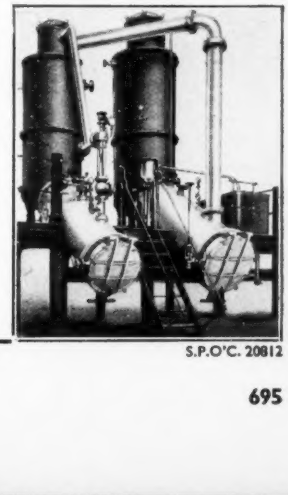

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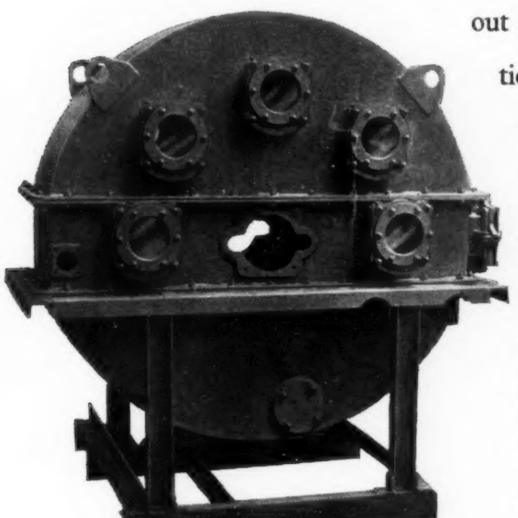

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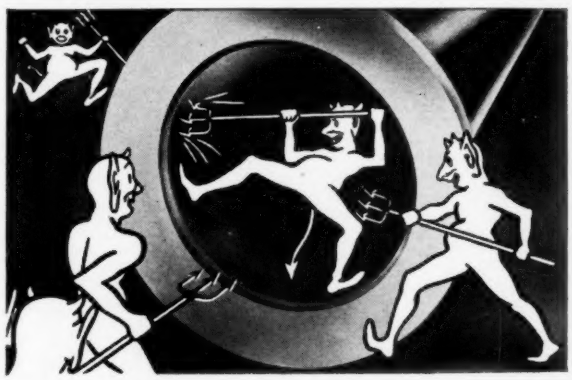

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